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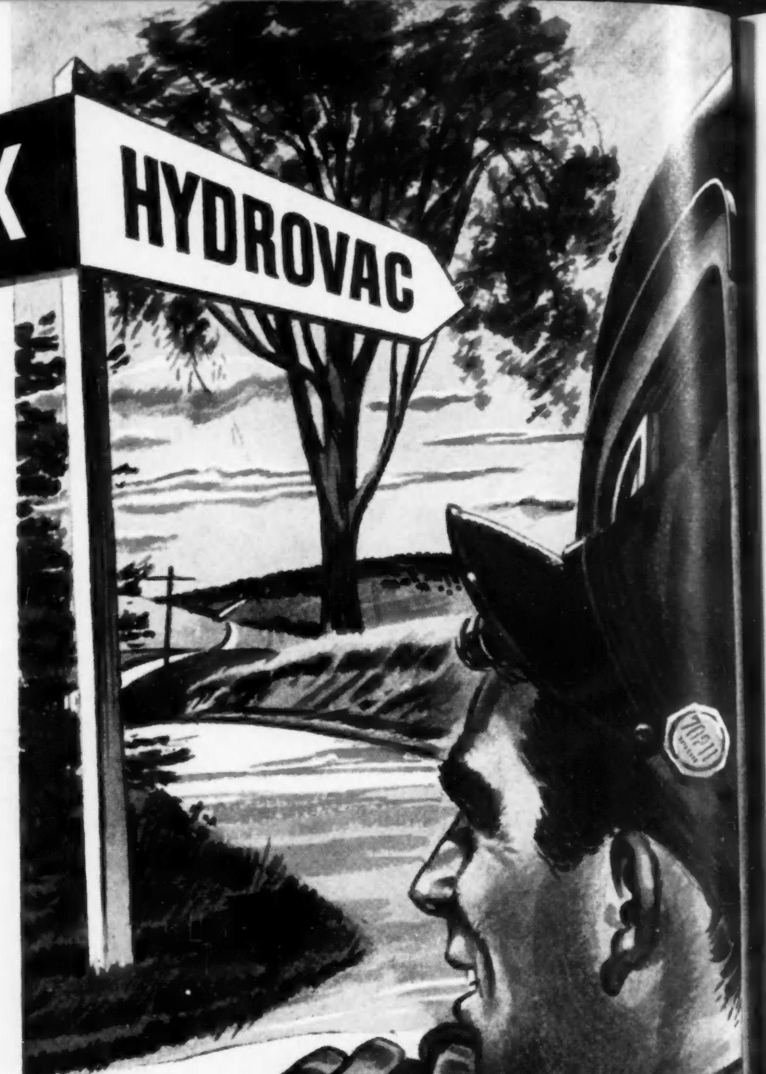
AIR-PAK
HYDROVAC

Seated behind the "round" table laden with automatic transmission parts are panel members (left to right) W. B. Herndon; F. R. McFarland; O. K. Kelley, moderator; R. J. Gorsky; A. H. Deimel; and R. L. McWilliams, panel secretary

Experts Discuss Automatic Transmissions

REPORTED BY

O. K. Kelley and R. L. McWilliams, General Motors Corp.

• Round Table on Automatic Transmissions was held at SAE Summer Meeting, French Lick, on June 7, 1951, under the auspices of the SAE Passenger Car Activity. Discussion leader was O. K. Kelley

DISCUSSION centered around automatic transmission clutches, oil pumps, shift problems, materials, and fluids.

W. B. Herndon of Detroit Transmission Division of GMC described a new variable-capacity pump that they expect to put into production on the Hydramatic in the very near future. He pointed out that the ideal pump at low speeds would have high capacity to meet the operating requirements of the transmission, and at high speeds needed but a low capacity. Such a pump would permit a reduction in power losses in the transmission. The new pump is a vane-type pump. In operation, vanes and rotor slide from neutral or no-output to full-output position, depending on the oil volume demand.

At one time in the evolution of the Hydramatic, planet pinion pins were breaking. At that time, they were made of alloy steel, case hardened. Then pins were changed to plain carbon steel, induction hardened in the center. The ends were left soft so that they could be swedged over in assembly. This change resulted in cheaper pinion pins that were at the same time more durable.

The constant search for better materials was exemplified in discussion of clutch plates. Originally, clutch plates were made of solid bronze, with spiral grooves, separated by steel discs. Later, sintered bronze plates were used. Now the material is cork and paper.

Currently, clutch plates are made by bonding cork and paper to a steel ring. The steel ring is waved to provide easy separation and soft application. Present plates have exceptionally long life and provide easy clutch application and disengagement. The present plate evolved out of trials of hundreds of materials and plate designs.

The early Hydramatic coupling was stamped and assembled with the vanes by crimping them. The first couplings made experimentally in this manner were noisy. One type of noise was easily eliminated by variable spacing of the vanes. Another noise was eliminated after experimentation by welding one end of the vane and leaving the other crimped.

With the introduction of the new Cadillac engine, Cadillac asked the Detroit Transmission Division to reduce the outside diameter of the fluid coupling. Reduction in OD of the fluid coupling meant a reduction in capacity unless other changes were also made. The capacity of the new fluid coupling with its smaller OD was maintained equal to the old coupling by using a double vortex system.

F. R. McFarland of Packard, in commenting on the Ultramatic, mentioned that in early experimental designs, they found that their clutch driven plate of the lock-up clutch had a tendency to break the splines on its shaft. Investigation revealed that torsional vibration was responsible for the failures. A change in the spring rate of the torsion damper corrected the difficulty.

He reported a unique method of breaking the sharp corners on oil holes, transverse to shaft axes. Packard simply places a rod across the hole at right angles to its axis, and imposes a measured load on the rod. This upsets the edges of the oil hole just

enough to eliminate the sharpness.

R. J. Gorsky of Buick reported a simple method of correcting the problem of having the clutch applied by the centrifugally created oil pressure. It was solved by the use of a ball check on the oil pressure side of the clutch piston. In operation, the oil pressure and the centrifugal force of the oil holds the ball on its seat. When the oil pressure is removed or reduced below a specified amount, the centrifugal force of the ball is sufficient to overcome the centrifugal force of the oil. Thus the ball will rise on its seat, or the ramp, and open the orifice, permitting the clutch to release.

A. H. Deimel of Spicer reported an interesting problem in connection with torque converter application on buses. In a certain installation, the engine stall speed was at times too high. After a number of repeated full-throttle starts, the converter lost its capacity and the engine would over run, resulting in faulty operation. After considerable testing, Spicer found that this occurrence disappeared after the converter had cooled. Investigation revealed that there was a minute quantity of water in the converter fluid. The repeated full-throttle starts raised the operating temperature to a point where the water vaporized, thus mixing steam in the fluid, and resulting in reduced density of the fluid medium. Replacement of the fluid with clean dry oil corrected the problem.

A question was raised concerning the necessity of using a special fluid such as the Type A fluid for automatic transmissions, or whether any good engine oil would be satisfactory. The resulting discussion emphasized that the Type A fluid as currently marketed was designed and developed along with the automatic transmissions just as all the other component parts of the transmission were developed. This oil is the result of repeated testing and development, and experience indicates that it is the proper one to use in automatic transmissions. It was agreed that automatic transmissions will operate on oils other than Type A, if operating temperatures are very low. However, the fluid in automatic transmissions must do more than simply lubricate. It also serves as a means of transferring energy. Therefore, it is subject to occasional overheating, and qualities of the oil such as oxidation, gum formation and other factors must be very carefully controlled to insure trouble-free operation.

As one discusser pointed out, the oil should be considered as a piece of the transmission. If Type A oil is specified, that is the kind that should be used to insure proper operation of the transmission under all circumstances.

The question was raised of dirt entering the transmission at inspection times, or at times when oil is added or replaced. It was agreed that extreme care should be taken at such times to see that foreign matter and dirt do not enter the transmission. However, even under the best of conditions, both manufacturing and in the field, it is impossible to insure that absolutely no dirt enters the transmission. Experience indicates that automatic transmissions will operate without too much difficulty under any normal presence of dirt that may enter.

One discusser pointed out that the presence of dirt dictated the use of sharp corners on sliding valves. With such corners, the valves tend to operate as scrapers and push the dirt out of the way. Chamfered corners on sliding valves tend to wedge the dirt under the valves, causing sticking and control failures.

One participant asked why two different patterns of shift ranges on the shift lever quadrant are used. Those present felt that a standard pattern should be used. The standard shift pattern that has evolved for conventional transmissions was cited as proof of the desirability of a standard shift.

Members of the panel were asked if any cases of transmission damage had been found due to the parking lock being accidentally engaged. No significant number of failures have occurred, was the consensus. It was pointed out that design of all parking locks is such that the pawl normally cannot fall into position if the car is in motion, even if the selector lever is moved to the park position. Furthermore, the parking lock is designed to withstand forces large enough to slide the rear wheels. Therefore, it would require high impact forces to damage the transmission if the car was parked with the lock engaged.

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Complete editorial coverage of the

1951 SAE National Tractor Meeting

The B-45 is a 100,000-lb-gross-weight bomber designed to operate at high speeds at high altitudes. Its four General Electric J-147 turbojets, each rated at 5200 lb static dry thrust, can propel the B-45 at 550 mph. Wing span is 89 ft. Wings are essentially without sweepback. All primary flight control surfaces are equipped with hydraulically actuated boost control systems. The tricycle landing gear, wing flaps, nose wheel steering, and main wheel brakes (both normal and emergency) are hydraulically operated

Flying the B-45 Jet Bomber

EXCERPTS FROM PAPER BY

N. N. Davis and E. M. Beattie, General Electric Co.

• Paper "Operational Experiences with Multi-Engine Jet Aircraft" was presented at SAE Aeronautic Meeting, New York, April 18, 1951.

OPERATIONAL experience with a North American B-45-C jet bomber in a flight-test program indicates that this type of airplane would perform satisfactorily as a jet transport.

Although the flight crew had no previous experience with jet aircraft, the General Electric Co.'s Flight Test Division had for several years been operating airplanes on high-altitude test flights in excess of 40,000 ft and had personnel in all three groups—operations, engineering and maintenance—with years of experience on such aircraft as the B-29, B-17, B-23, DC-6, DC-4, and Convair.

Routine test flights were begun in August, but proceeded slowly at first because of fuel and hydraulic leaks common to any airplanes which have been completely inactive for several months. However, as the personnel became more familiar with the equipment, it was possible to increase the number of flights. During the winter month of January, 1951, with favorable weather conditions, 21 flights accumulated a total of 47 hr. Because the runways at Schenectady are only 5000 ft long, no attempt was made to fly when they were covered with snow or ice.

The four engines in the B-45 are started individually, as very conservative starting procedures are used in this program. Approximately 9 min total time is required to reach normal idling speed on all engines. This requires 50 gal of fuel. The starting fire hazard and the complexity of cockpit controls are much less with a jet engine than with a piston engine. This would certainly permit the pilot and copilot in a side-by-side cockpit to start engines simultaneously, thus cutting the time and fuel consumption in half. However, the initial electrical starting load per engine with a 28-v dc system must be suitably designed for high multiple-engine starting loads, and ground power units much larger than those used today will be required.

Idle power, 38% of maximum allowable rpm, is ample for taxiing requirements and does not produce any more air disturbance on the apron than large piston-engine aircraft. Our experience shows that it takes about 15 min in the B-45 from the time the first starter switch is actuated until the pilot is ready to take off, and that 200 gal of fuel are consumed.

Pilot checklist requirements on the jet airplane and conventional airplane are similar until the "Before-Take-Off" checklist is reached. Here the simplicity of the jet engine helps because the aircraft can take position on the active runway almost immediately after the engines are started. The four

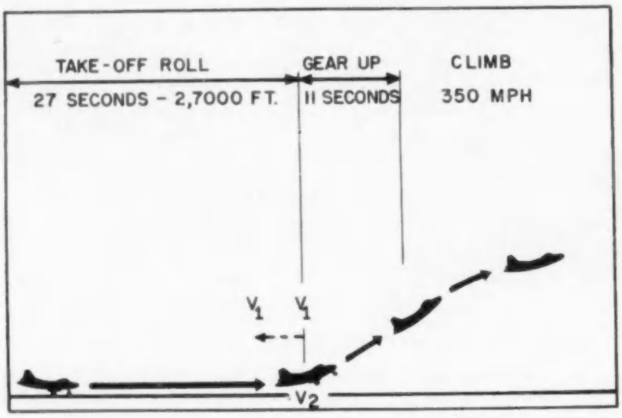

Fig. 1—B-45 take-off

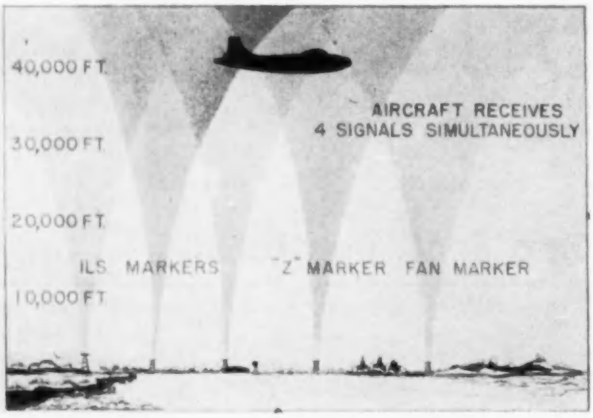

Fig. 2—High-altitude radio marker beacon interference

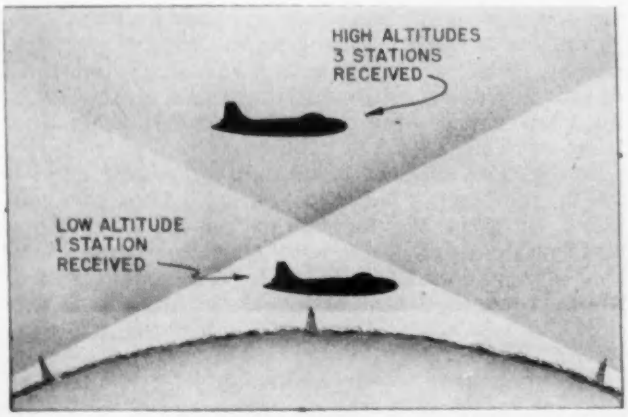

Fig. 3—High-altitude VHF radio congestion

power controls are simultaneously advanced to 100% rpm; fuel pressure, oil pressures, and tailpipe temperatures are checked; brakes released; and the take-off begins. Compare this procedure with the requirements of the piston-engine in which propeller controls, magnetos, engine blowers, or superchargers, and carburetor heat must be checked. Furthermore, the pilot with the piston-engine is unable to check his engine instruments completely at 100% power until well into the take-off distance, and is often at considerable disadvantage because of attempting to read vibrating instruments on a rough runway. The added assurance of correct engine operation at full power greatly alleviates the mental problem of the jet pilot in planning for accelerate-stop requirements.

We have accumulated more than 175 hr. per engine, or a total of 746 engine-hours, with relatively minor maintenance required to date. For the initial 125-hr. flight time, practically no maintenance other than routine servicing was required. During the program, we have experienced only one instance of serious mechanical malfunctioning. In this, a turbine wheel was found to have several cracked buckets after accumulating 175 hr. The emergency fuel regulator system, although never used, has caused us some trouble, but in every instance we have merely isolated the regulator and continued flying. We do not think it is necessary to incorporate an emergency stand-by regulator system on a multi-engine jet airplane.

We have found that the number of man-hours expended on engine inspection and maintenance is less than half of that experienced with piston engines.

The CAR transport category requirements are used for all airplanes operated at our Flight Test Division in determining the maximum gross weight allowable for take-off. Consequently, during this series of tests, the B-45 was operated at 75,000 lb. maximum weight to meet accelerate-stop requirements, which were the most critical of items on the 5000-ft runways. Since there is no minimum control speed on the ground, the V_1 speed is equal to the V_2 speed for the above gross weight. If an arbitrary V_1 speed is selected to meet accelerate-stop requirements only, the selection of 120 mph would permit a take-off gross weight of approximately 87,000 lb. Fuel loads of 3700–4000 gal have been used for our test flights to date.

With all engines stabilized at take-off power prior to releasing the brakes, the pilot is free to devote much more attention to the take-off, although it is necessary to watch tailpipe temperatures, which characteristically increase slightly during the take-off and initial climb. Approximately 8 min at 100% power is required to reach a stabilized engine tailpipe temperature. Changes in ambient ground temperature also affect tailpipe temperature from day to day, and we have found that the best maintenance procedure is to set tailpipe temperature approximately 10 C low at initial 100% power settings.

The average take-off is accomplished in 27 sec with a ground roll of 2700 ft and a take-off speed of 130–135 mph. (See Fig. 1.) Due to the low limiting air speed of 185 mph for extended gear and flaps, the initial climb must be very steep until gear retraction, which requires 11 sec, is completed. Normal initial

climbing speed is 350 mph at 100% power. Note again the simplicity of jet engine operation, with no power reduction required after take-off. However, since no factual data have been obtained on the increase in engine time to overhaul when consistently using reduced power, we have been operating two of our engines at 97% rpm, and limiting the continuous full power time to 30 min. This investigation may result in recommendations for reducing power after take-off to achieve longer life operation.

Fuel Consumption

The inherent high fuel consumption per mile of the jet airplane at low altitudes makes it economically advisable to give traffic clearance priority to the jet. Fuel consumption during take-off or initial climb (low altitude) is approximately 57 gal per min on the B-45 we are operating. However, if the jet is forced to follow a traffic clearance for a short time at 5000 ft, power can be reduced to maintain air speeds below 200 mph and fuel consumption reduced to approximately 1000 gal per hr. If the ultimate, initially desired, cruising altitude is 35,000 ft, and the jet was held down to low speed and altitude for 15 min before being allowed to climb to cruising altitude, it would experience a net loss of 9 min in time, 115 gal in fuel, and 70 miles in distance.

Icing conditions have been encountered on several flights at various altitudes up to 20,000 ft. In every case experienced so far, it could be dissipated by increasing the air speed without using the thermal anti-icing system. However, upon landing shortly after encountering icing conditions during a descent, ice has been found on the compressor inlet screens. Anti-iced engines have not been installed on this airplane. With the advancements presently being made in jet engine anti-icing, the entire icing problem appears to be greatly reduced with the jet airplane.

The problem of turbulence at high altitudes, 35,000 to 40,000 ft, has proved to be negligible. However, in the region between 25,000 and 35,000 ft, we have experienced turbulence in clear air or in cirrus clouds of sufficient intensity to call for a precautionary reduction in air speed during high-speed descents. This turbulence, which produces accelerations of approximately one G, is of high frequency and short duration, and very stratified.

Air for cabin pressurizing, wing thermal anti-icing, and cabin heating is furnished by bleeding air from the compressor sections of each of the four engines. None of the pressurizing, heating, and ventilation controls or equipment has given the least bit of trouble since we have been operating the airplane, and the flight crew consider the system to be functionally superior to any now available in piston-engine type airplanes.

Our only criticism is directed at the large quantities of snow and ice produced in the ducts on humid days by the dual expansion-turbine cooling units. Rapid descents or climbs of 3000-5000 ft per min do not appreciably affect the cabin pressure.

One case of explosive decompression has occurred at an altitude of 36,000 ft with a cabin differential pressure of 6.5 psi, in which a large section of the pilot's plexiglass canopy failed completely. No primary structural damage resulted, and the crew, while suffering discomfort, made a safe descent and normal landing.

Cruising at high altitudes has raised several questions concerning radio facilities and reception. It is common at 35,000 or 40,000 ft to arrive in the vicinity of a radio range station and through the marker receiver to hear simultaneously for several minutes two or more fan markers, one or two ILS markers and the Z marker, while the ADF needle swings irregularly for a protracted period of time. (See Fig. 2.) As a result, the exact time of passing over such a point is difficult to determine. Omniranges may help but as yet they are not in universal use. Communication, too, has its drawbacks in that high altitude brings in so many stations on VHF that at times those very high frequencies become as cluttered as the old high frequencies. (Fig. 3 illustrates this condition.)

Descents in the B-45 from 35,000 ft to an approach pattern at a sea-level airport take about 8 to 10 min and are limited only by the allowable Mach number. For maximum range, however, a descent at the rate of 2000 ft per min should be maintained, requiring 17.5 min and covering a distance of 100 miles. The initial rate of descent from 4,000 ft and above is restricted by Mach limitation to such a point that only 500 to 700 ft per min can be expected. It is in this condition that dive brakes—which the B-45 does not have—would be of great value. Under such circumstances, it is standard practice to cut one or more engine, which can be done without jeopardizing cabin pressurization, thereby eliminating thrust and

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GE Tests J-47's in B-45

THROUGH the foresight of the U. S. Air Force Air Materiel Command, a North American B-45-C four-engine jet bomber was made available to the Aircraft Gas Turbine Divisions of the General Electric Co. for the purpose of conducting accelerated service tests on its J-47 engines. The large amount of flying associated with this test program has enabled the flight crew to become well acquainted with the factors involved in operating multi-engine jet aircraft on representative missions.

The authors of the accompanying article, Messrs. Davis and Beatty, are American Airlines pilots assigned full-time to the General Electric B-45 flight test project crew under a contract American has with GE.

In general design, the B-45 bomber is the nearest thing to a jet transport that the United States has flying today.

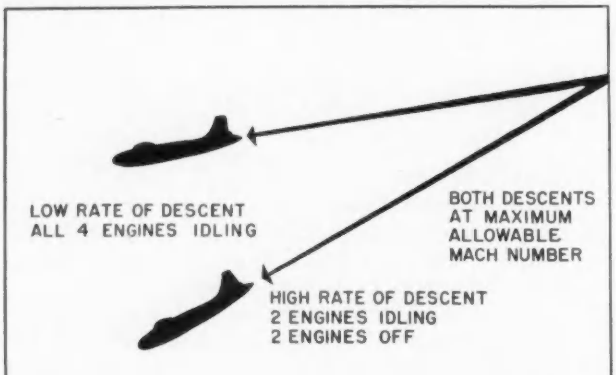

Fig. 4—Maximum rates of descent

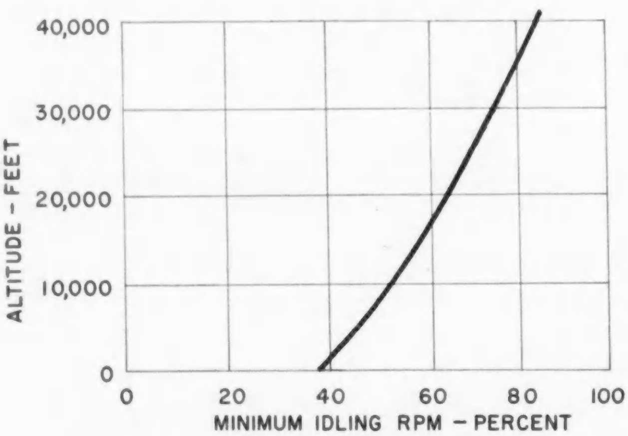

Fig. 5—Minimum idling rpm versus altitude

boosting the rate of descent, and at the same time conserving fuel. (See Fig. 4.)

The fundamental operating characteristics of the axial-flow turbojet engine require a certain minimum engine speed to permit acceleration at any altitude. Hence the minimum allowable rpm of the jet engine increases with altitude. (See Fig. 5.) This minimum allowable rpm is controlled by automatic devices working in conjunction with the fuel regulator, so that even though the power controls are retarded to the idle position, the engine rpm and thrust will not decrease below a scheduled value. Consequently, if it is desired to reduce engine power or thrust substantially at high altitude, one or more engines must be shut down.

Since exhaust gas temperature affects the life of the turbine buckets so vitally, care must be used when shutting off the engine if maximum life is to be attained. Whether on the ground or in flight, the power control should be retarded until minimum rpm, or the idle stop, is reached. Allow the tailpipe temperature to stabilize at this lower value for approximately 1 min and then cut the engine. No case of "flame-out," a word commonly associated with earlier jet engines, has ever occurred during our flights.

The problem of instrument flying in jet aircraft is, we believe, a neglected subject. The technique involved differs little, if any, from that applied to conventional aircraft, but acceptable let-down and approach procedures are lacking. For example, the procedure for Berry Field, Nashville, Tenn., as it appears in the pilot's handbook published by the Aeronautical Chart Service in Washington, D. C., calls for an initial approach over the range station at 15,000 ft, or 500 ft above the undercast, whichever is lower. (See Fig. 6.) Then, on a heading of 280 deg, the pilot is to proceed from the range 2 min and begin descent at 3000 ft per min and 300 mph continuing to hold the 280 deg heading until reaching the minimum authorized altitude of 3500 ft.

Assuming the descent was begun from 15,000 ft, the airplane is over 30 miles from the airport at 3500 ft on completion of the descent and must be VFR at that point before the pilot can head for the field where minima must be 3500 ft and 3 miles. If he is not VFR, instructions state he must climb to 5000 ft continuing on the 280 deg heading and ask for instructions from Nashville Approach Control. By this time, he is 50 miles away from Nashville and must obtain clearance to climb to optimum altitude by any means available to him so that he may proceed toward his alternate. That such a procedure is impractical is admitted by all concerned including the Air Force, which has stamped its handbook "Experimental."

In a more realistic approach to the problem, the jet pilot will use established procedures for conventional airplanes with slight variations where needed. A standard range approach is practicable in the B-45 at 160 to 18 mph IAS with gear down and flaps extended 20 deg, and ILS can be used with equal facility under the same configuration. However, getting the jet aircraft down to a suitable altitude for higher system without penalizing its advantage of fast descent poses a problem. For example, if the B-45 could descend from 35,000 ft in 10 min at 400 mph and, with the aid of dive brakes and landing gear, slow to 180 mph before entering a holding or approach pattern, the problem would be relatively simple. However, precise instrument flying requires reduced speed. It is apparent that faster airplanes are at a greater disadvantage and such aids are necessary. We believe that nondirectional radio beacons remotely situated in areas sur-

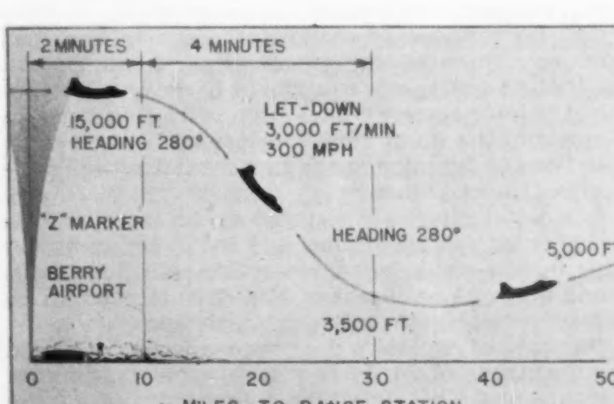

Fig. 6—Nashville jet instrument let-down procedure

rounding airports would be of benefit in descending and holding.

We have accepted as standard the practice of shutting down one or two engines to extend holding time when necessary, as air restarts are sure and fast. Since fuel economy at holding speeds (maximum endurance) is much the same regardless of altitude, the problem of holding can be resolved into the probability of having to proceed to an alternate airport. Here the jet is at an extreme disadvantage if holding at low altitude. As an example, if the B-45 were holding at 5000 ft with X amount of fuel remaining and had to proceed to an alternate airport, it could continue flying at 5000 ft for a distance of 700 miles; or it could climb to 35,000 feet and thereby extend its range to 1040 miles including the climbing distance. However, if holding at 35,000 ft, with the same X amount of fuel remaining, it could continue for 1250 miles. (See Fig. 7.) Consequently, if we are thinking of scheduled operations over so-called high-density routes, the problem of letting down and landing under unfavorable instrument conditions emphasizes the need for long runways if the control is to be kept in the cockpit, and, even more emphatically, demonstrates that the future of both departing and arriving traffic control lies in some form of ground control.

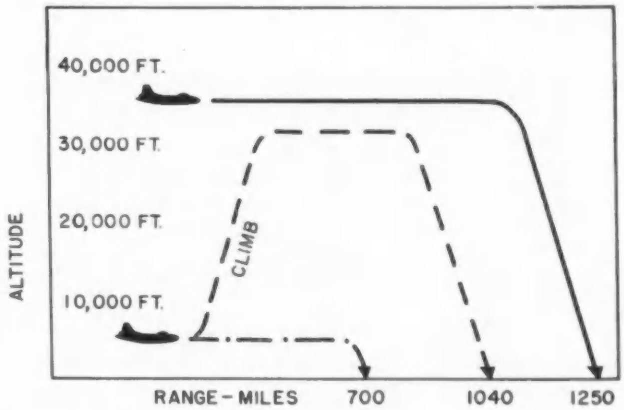

Fig. 7—Range advantage from high-altitude holding

Approach to a landing penalizes the B-45 because of its very low gear-extended speed of 185 mph. After a fast descent at high speed, time is wasted while waiting for the air speed to diminish or while accomplishing a pull-up to attain the same result. A permissible gear-extended speed of at least 350 mph, or dive flaps, would not only save time but would permit a faster rate of descent as slower air speeds, thus reducing the turbulence effects at lower altitudes.

The severest criticism of the jet engine, however, has been its slow acceleration response, particularly on a go-around. It has been said almost repeatedly that a jet cannot go around and that it is committed to a landing almost from the time it enters final approach. This has not been borne out in our experience—we have made go-arounds and touch-and-go landings with about the same results as with conventional aircraft. It is not necessary, and it is unwise, to reduce rpm to the idle setting during final approach until the very last instant before the wheels contact the runway. The entire approach can be made at 60% rpm, or more, from which power response compares favorably with that of a piston engine. Air speed should be controlled by sensible use of the wing flaps, not by reducing power to idle rpm from which acceleration to top speed requires 15 sec or more.

Braking

The favorable comparison of the jet to the propeller airplane ceases when the wheels touch the ground. Although the final approach air speed of the B-45 is only slightly higher than that of such airplanes as the B-29, there is a distressing lack of propeller drag for initially slowing down the jet airplane. Bringing the airplane to a stop with brakes alone is feasible on a wet macadam runway. The more unfavorable braking action on ice or snow renders operation on 5000-ft runways impossible, and even makes operation on wet concrete questionable. Only runways of extreme length can be used for snow or iced runway operation. On dry macadam runways, the B-45 can be consistently braked to a stop, over a 50-ft obstacle, in 4000 ft or less at gross weights of 55,000-70,000 lb. We have been using 32-ply, high-pressure, ribbed-tread tires and Goodrich expander-tube hydraulic brakes. Extrapolating our expected tire life from the number of landings and wear on the tires to date, they should last for approximately 200-300 landings. We have no yardstick to judge brake assembly life—the brakes and drums show almost negligible wear.

The emergency hydraulic brake system with which this plane is equipped is recommended for a jet airplane over the now conventional emergency air-brake system used on present propeller-type aircraft.

Some increase in braking efficiency may be possible with various anti-skid devices now being developed, but these devices will not appreciably shorten the landing roll distance of the tricycle-gear airplane above that obtained with normal pilot technique. However, anti-skid devices for the bicycle type gear, where the pilot has no feel of the relative weight borne by each gear, should be of immense value. The use of drag parachutes may be adaptable for special military purposes, but may be too unwieldly and undependable for transportation operation.

The advantage of reverse thrust with propeller-type airplanes on slippery runways is well known, and we do not believe any type of brake can bring the jet up to the controllability level of present transport airplanes until reverse thrust is added to the jet. Consequently, we can see no relief in the near future for jet transport operators if forced to land on slippery runways with the equipment available today. On the other hand, we know of no reason why a jet transport airplane could not operate safely today from most of our airports if restricted to dry runways and the general airplane configuration—that is, gross weight, wing loading, and braking efficiency—is comparable to the B-45.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Latest

USE of a gas turbine engine as the prime mover in heavy duty trucks has a number of definite advantages:

1. Light weight—the engine has almost a 3000 lb weight advantage over diesel engines of comparable power now used on west coast

2. Much smaller space requirements for installation

3. Smaller, lighter, and fewer parts—requires approximately 10% as many parts as the average reciprocating engine

4. Complete absence of vibration

5. Adaptability to a variety of fuels, particularly very low grade fuels

6. Easy maintenance—due to the small number and light weight of parts

7. Good cold-starting characteristics

8. Maximum fuel economy with maximum engine output

9. Low consumption of lubricating oil

10. Immediate availability of full horsepower

However, these disadvantages offset the above advantages to a measurable degree:

1. Higher fuel consumption than piston engines in all ranges

2. Parts most subject to failure are high cost parts

ONE year ago, feasibility of using a gas turbine engine as motive power for heavy duty truck operations was being discussed entirely on a speculative basis. Today, development of this new type of power has still not progressed to the point that a completely factual analysis of the engine's worth in this application can be made.

The actual testing program has been conducted and supervised by Boeing Airplane Company personnel under the sponsorship of the Navy Department Bureau of Ships. Kenworth's part has been that of a very interested onlooker and confidant.

The truck has a conventional chassis with certain modifications to allow for installation of the engine and an experimental semi-automatic planetary transmission, also being tested. Fig. 1 shows the test truck arrangement. At the left is the turbine engine. Directly under the cab fire wall is the marine reverse gear used to change the engine rotation into normal automotive rotation. The unit under the back of the cab is the seven speed semi-automatic transmission being tested. The next gear box is a standard heavy duty auxiliary transmission. One exhaust stack is shown in the outline. (There are two on the test unit.) From this drawing, it can be seen that very little modification was made to the vehicle.

Fig. 2 shows diagrammatically the operation of the gas turbine engine. The engine being tested consists of the Boeing model 500 jet section, less the cone to the rear of the first turbine wheel. This section has a self-contained oil burner which generates the hot gases that are run through the second stage turbine wheel to produce the output shaft horsepower.

After the engine is started by an electric starter, the hot gases which pass through the first stage wheel produce the power to (1) turn the air compressor at the front of the engine, (2) pump the fuel through the spray nozzles, and (3) run the other accessory equipment.

As the first and second turbine wheels have no mechanical connection between them, the second stage functions as a driven unit in a gas torque converter. The torque multiplication at stall of the second stage is approximately 2 to 1. The shaft speeds and temperatures shown on the diagram are the maximum for normal operating speeds. Normal rated horsepower of the engine is 175 hp at 2500 shaft rpm. But laboratory tests at slightly higher

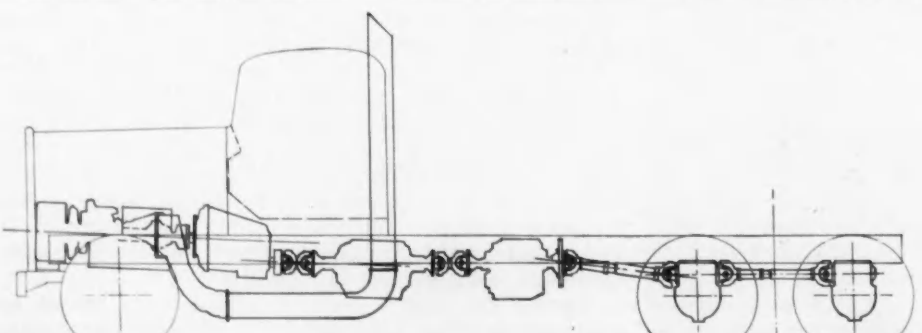

Fig. 1—Test truck arrangement consists of (left to right) the turbine engine, marine reverse gear, semi-automatic planetary transmission, and standard heavy duty auxiliary transmission

Facts About Turbine–Driven Trucks

BASED ON PAPER BY

R. C. Norrie, Kenworth Motor Truck Corp.

• Paper, "The Turbine Test Truck," was presented at SAE National West Coast Meeting, Seattle, on Aug. 14, 1951.

shaft speeds and air temperatures indicated that it might not be very difficult to increase the horsepower output to over 200 hp.

This engine has the unique characteristic that it can be started and brought up to full power output without any warm-up. The motor is started by turning on the fuel and pushing an electric pushbutton which actuates the electric starting motor and spark igniters. The electric starter is capable of turning over the primary stage to a speed of approximately 3500 rpm. Combustion of the fuel takes place before this speed is reached and the primary stage runs on up to idling speed, which is 15,000 rpm. Upon reaching this speed, the pushbutton is released and the engine carried on up by the foot accelerator to normal operating speed of 36,000 rpm. The starting period is less than 15 sec and the acceleration period is 5 sec. Therefore, from a dead cold start, it is possible to take full power out of the engine within 20 sec after power is required.

The primary purpose of the test program was to increase the reliability of the engine. Comparison of relative test mileages obtained under various loading conditions will best serve to illustrate the great improvement in reliability during the testing period.

The engine was installed in the truck chassis in March of 1950. During the first test period, which ran through July of 1950, the truck was operated as a solo unit at a gross vehicle weight of 30,000 lb. It was then converted into a tractor, semi-trailer combination, and some tests were made at a gross vehicle weight of 67,300 lb. The loading was then reduced to 54,000 lb for the second test period which ran through January of 1951. At this time, the weight was increased to 68,000 lb and a third test period begun.

The test mileage for the last four months period was approximately 10% greater than that of the first two test periods which consumed about 10 months. Furthermore, the test mileage during the last month of operation was 50% greater than the mileage during the first period of four and one-half months and equal to five and one-half months of operation during the second period.

Thus it can readily be seen that the reliability of the engine has measurably improved. However, the replacement and repair of certain parts, now measured in hundreds of hours of engine life, will have to be measured in thousands of hours of engine life before commercial operators of heavy duty motor vehicles will be satisfied.

While engine fuel consumption has not been vigorously attacked during the truck test program, some gains have been made. Consumption still runs between 3 and 4 times that of a diesel engine burning identical fuel and hauling the same gross load. But it is entirely possible and forseeable that the fuel economy can be greatly improved.

The engine is now ready for the services for which it was originally conceived. The military services will need all that can be produced for some period of time. But the commercial gas turbine truck is on the road, headed this way and coming fast.

(Paper on which this abridgment is based is available in full in multilithographed form from the SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

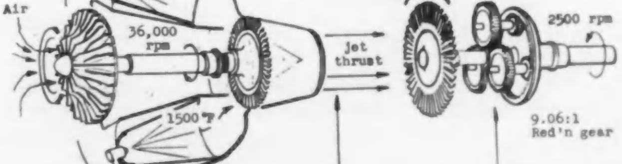

Fig. 2—A self-contained oil burner generates the hot gases that are run through the second stage turbine wheel to produce the output shaft horsepower

Diesel Fuel Problems—

THE preparation of a specification consists of more than setting down a list of physical requirements. It should describe the widest range of fuel quality the engine will satisfactorily burn. It must be flexible enough to satisfy the limits prescribed by the engine builders and at the same time give the purchasing agent enough latitude to allow him to take advantage of price differentials based on quality. The B & O specification for diesel fuel oil is an example of an attempt in that direction.

The specified limits of five engine builders had to be combined into one specification to satisfy the requirements of all five, no two of which were identical. Freedom of purchasing range based on quality classication also had to be introduced.

To accomplish this, two important properties of the fuel were considered. These were the ignition quality as reflected by the cetane number and the sulfur content. Increasing the allowable sulfur content was eliminated for the present because the effect of higher sulfur fuels upon railroad engine maintenance cost had not been clearly established. Service tests indicated, however, that cetane could be reduced if such a step became necessary.

As late as 1947 most railroads specified straight-run diesel fuel of 50 minimum cetane number. However, with the trend toward the use of more cracked stocks in diesel fuel, we found it advisable to classify the fuel by cetane number. Class A being 50 and over, B ranging from 45 to 50, and C from 40 to 45. This has been a useful aid in classifying fuel quality for purchasing purposes.

Further changes and greater agreement relative to fuel specification may result from the numerous service tests now under way. It is expected that future specifications will more accurately describe the requirements of the engines in actual service.

Checking Shipments in Field, Laboratory

Railroads have learned by experience the importance of clean fuel. The engines told them in emphatic terms. They simply stopped running when injectors stuck or filters plugged. Although the fuel supplier generally follows well-known and standardized methods for maintaining the delivery of clean fuel, sources of contamination do exist. They are:

1. Water, scale, and rust from improperly cleaned delivery tanks, especially those that have previously carried aviation gasoline.
2. Water, impurities, and products of instability from storage tanks.
3. Dirt from unclean handling equipment and transfer lines.

The incidence of fuel contamination is so prevalent that some method had to be devised to inspect the 26 tank cars of fuel that are unloaded by the railroad each day. Since these are constantly arriving at widely separated fueling stations along the line of the road, time and distance preclude the analysis of a sample from each car in the chemical laboratory before it is unloaded. Therefore, a field method had to be devised because individual cars are frequent offenders. We redesigned the common barrel thief to make it semi-automatic. It enables the storekeeper to obtain a sample from the bottom of the car and inspect it for visable impurities. The amount from free water is determined simultaneously while getting the bottom sample by using water-finding paste on the graduated end of the sampler. If dirt, cloud, or unusual color is observed when the sample is inspected in good light in a pint glass bottle, the car is held under load. Another

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RAILROADS with diesel locomotives use a lot of fuel oil. For example, the B & O needs about 5,000,000 gal a month at widely separated points.

The handling of this large amount of fuel introduces a number of problems, including the following:

1. The preparation of specifications designating and classifying the type of fuel acceptable.

2. The development of a means of inspecting tank car shipments in the field and in the laboratory.

3. The development of means of handling the fuel at storage points.

4. Storage stability and tank corrosion problems.

The authors' discussion of these problems is presented in the accompanying article.

Storage and Handling

EXCERPTS FROM PAPER BY

R. W. Seniff and H. D. Plumly, B & O Railroad Co.

* Paper, "Diesel Fuel Problems; Storage and Handling," was presented before the St. Louis Section of the SAE, St. Louis, Mo., Dec. 12, 1950.

sample is taken from the middle of the car and both bottom and middle samples are sent to the laboratory. The disposition of the car is then determined by laboratory analysis. This avoids unnecessary demurrage on cars and insures 100% inspection at minimum cost.

Once a month a complete laboratory analysis is run on the fuel from each supplier. This establishes trends in quality and uniformity of fuel from the various vendors and, combined with the individual car inspections described above, comprises a thorough inspection system. A monthly report of these analyses is supplied to the purchasing agent, mechanical department, and fuel department of the railroad. Descrepancies in quality are promptly handled with the vendors, who are always prompt in making corrections.

Fuel Transfer and Storage Systems

A typical railroad fuel transfer system includes the connection from the tank car through a strainer, pump, filters, air eliminator, and meter to the storage tank. The same pipe and equipment is generally arranged to deliver the fuel from the storage tank to the locomotive. Particular precautions are taken to protect the discharge and delivery hoses from dirt and water. In most cases they swing from a boom, which prevents them from touching the ground.

Most railroads store large amounts of fuel in relatively large, vertical tanks. Some are provided with a water sump or sloping bottom so that the water and solid impurities that precipitate are collected in one place and can be easily drawn off. Some railroads still use "water bottom" tanks, although it appears that many oil companies have discontinued them in favor of the sump type, because of lower tank maintenance costs of the latter. Swinging draw-off pipes for drawing the fuel to the engines from near the top of the fuel in the tanks are desirable and widely used. Fixed fuel draw-off lines are located well above any anticipated level of settled water. Frequent water removal is important for two reasons. First, there is danger of getting water in the fuel being delivered to an engine. Second, the water in the storage tank may become corrosive by dissolving corrosive products from the fuel oil. Where "water bottom" storage tanks are used water samples from the tank are periodically tested for corrosiveness. The water is changed if the pH drops below 7.0. A vent, well removed from any source of flame, is used to permit the escape of volatile gases. An air filter on the vent is desirable. A ground connection is provided to dissipate static electrical charges and a Foamite system should be readily available for fire protection.

Railroad Storage Tank Contaminants

One source of contamination comes from the humid air drawn into the tank as fuel is withdrawn and by the expansion and contraction of the fuel and the tank atmosphere with temperature changes. The water which condenses is no problem if it settles to the bottom and is periodically drawn off. However, the moisture which condenses on the interior tank surfaces rusts them, causing pitting and scale formation. In time, fuel turbulence, thermal expansion, or vibration of the tank cause these rust particles to drop off. Airborne dirt is not a problem where tanks are properly constructed and maintained.

Diesel fuel oil oxidation or polymerization in storage has not been a frequent problem but cases have occurred that caused engine failures. Stability in storage is therefore important. Better tests for this characteristic are unsolved problems. The cetane number of the fuel used by railroads represents a relatively high paraffin content, which has inherent stability. However, the trend in railroad diesel fuels is toward the use of blends that contain cracked stock. Some of these blends are not as stable as the straight-run products. Some products of instable fuel dissolve in water and corrode the steel storage tanks and diesel fuel systems, especially the injection equipment. Other products form precipitates, cause filtration problems. If this process occurs in the diesel locomotive, engine failure may result.

Although it is not a fuel contaminant in the strict sense, the precipitation of wax crystals from the fuel at low temperature has the same effect as dirt on filter stoppage. The cloud point of a fuel is more important than the pour point because the small

Continued on Page 31

Fig. 1—The 2½-ton, 6 × 6, M34 cargo truck, a postwar vehicle that is being mass produced today

Military

TYPES of trucks and components required for military wheeled vehicles are many and varied. The military must—in many cases—have a special, completely different vehicle from that designed for and used in commercial operation. In the design of standard commercial equipment, cost and sales appeal are of prime importance. But with military vehicles, the primary concern is to have a vehicle that will carry its load to the proper destination under whatever conditions of terrain and weather exist. Performance, maintainability and dependability are the goals. Cost is a secondary consideration.

Fig. 2—The 5-ton, 6 × 6, T51 cross-country carrier, now in the pilot stage, appears to be a wheeled vehicle that can keep up with tanks over any type of terrain

At the beginning of the last war, it was necessary to take standard commercial trucks and use them as tactical military vehicles. During the course of the war, these vehicles exhibited a number of serious deficiencies.

1. Loss of mobility—often due to the differential, which permitted dissipation of tractive effort through slipping of the least tractive wheels.

2. Inadequate axle clearance—trucks frequently found themselves resting on their axles in deep ruts.

3. Flotation—an important factor affecting the vehicle's ability to cover any type of ground surface.

4. Brakes—mud, sand and salt quickly destroyed brake drums, brake linings, and operating mechanisms.

5. Suspension—great spring mortality often meant destroying a vehicle rather than abandon it to the enemy.

6. Riding comfort—anyone who drove a truck can testify that riding qualities were not beyond criticism.

7. Time required for repair—not so much the time to effect the repair itself but the time-consuming uncovering operations.

Fig. 3—The World War II wheeled vehicle nearest to the capacity of the T51 is the 4-ton, 6 × 6 cargo truck, which lacks many of the outstanding features found in its postwar counterpart

Ordnance engineers fully realized when they undertook the design and development of ideal wheeled tactical vehicles that it would be a time-consuming and difficult task. Therefore, this dual program was initiated; (1) to carry on the development of the ideal military wheeled vehicle, and (2)

Wheeled Vehicle Needs

BASED ON PAPER BY

Col. William A. Call, Chief, Development and Engineering Department, Ordnance Tank-Automotive Center

• Paper, "Military Wheeled Transport Vehicle Requirements," was presented at SAE Summer Meeting, French Lick, on June 4, 1951 and at SAE National West Coast Meeting, Seattle, on Aug. 13, 1951.

to carry on the development of a vehicle that can be produced in quantity today.

The postwar 2½ ton M34 cargo truck, shown in Fig. 1, is an example of the second objective. Other trucks in this category are a ¼ ton, ¾ ton, alternate 2½ ton, and a 5 ton.

Simultaneously, investigations and attempts are being made to develop ideal wheeled vehicles. The payoff lies not solely in the development of an ultimate vehicle, but also in the interim application to current production of lessons learned piecemeal and separate components developed in the course of the long-range program. Ideal vehicles will be equipped with:

1. Locking or semi-locking differentials;
2. Completely sealed braking systems;
3. A torsion bar or some other suspension system which will give increased road clearance;
4. Extremely large and soft tires to increase ground clearance, give a better ride, and increase mobility over soft surfaces;
5. Standard Ordnance engines;
6. Some type of torque converter or automatic transmission.

As mentioned previously, development of the so-called "perfect tactical vehicle" will require great effort over an extended period of time. However, some of the desirable features are being incorporated in present-day vehicles. For example, the M-34, 2½-ton trucks have been improved transmission-wise by incorporation of synchromesh features. And use of an automatic transmission with an alternate 2½-ton truck is now under consideration. The engines in these production vehicles are essentially commercial truck engines, modified to incorporate a 24 v electrical system which is completely shielded and waterproofed. They will operate completely submerged, requiring only the addition of an air intake pipe and an exhaust extension. Ease of maintenance has been given keen attention by industry engineers—and with a great deal of success. Mechanics at the tire test fleet operations in Texas are pulling the complete powerplant of the M34 in 18 min. Consider what that means to the harassed mechanic in a combat outfit. He can replace a faulty power package in much less than an hour. Then, with the truck back on the road, the faulty power package can be repaired in a shop when time permits.

While these desirable changes are being incorporated into present high volume production models, the building and testing of experimental models of more advanced tactical vehicles continues. It will be interesting to compare one of the tactical vehicles now in the pilot stage to World War II wheeled and tracked vehicles of the same capacity.

Take, for example, the T51 cross-country carrier, which has a payload of 5 tons. (See Fig. 2.) The World War II wheeled vehicle nearest this capacity was the 4-ton 6 × 6 cargo truck (Fig. 3), and the nearest tracked vehicle was the M8 cargo tractor, with a capacity of 5 tons. (See Fig. 4.) The T51 weighs 1½ tons less than its World War II counterpart and less than half as much as the tracked vehicle. It has the same width as the World War II wheeled vehicle and is substantially narrower than the tracked vehicle. Its height is lower and its ground clearance, 15½ in., lies midway between that of the two World War II vehicles. It has a 100%

Fig. 4—The postwar T51 is superior in many ways to its comparable capacity World War II tracked vehicle, the 5-ton, M8 cargo tractor

Fig. 5—The deep water fording kit enables vehicles to negotiate streams up to the depth of the driver's neck

higher horsepower than the World War II wheeled vehicle and approximately half the horsepower of the World War II tracked vehicle. T51 road speed is higher than either of the World War II vehicles. And it will ford streams to a depth of 6 ft, whereas both the World War II vehicles were limited to 36 in. of water. It also has a substantially greater cruising radius and will climb steeper grades at higher speeds.

Actually, the T51 appears to be a wheeled vehicle capable of keeping up with tanks over any type of terrain. Other advantages include a more comfortable ride; easier to drive; maintenance is relatively simple; and it incorporates a completely waterproof, corrosion-proof, fungi-proof, dust-proof and radio-interference-proof, 24 v ignition system.

In addition to the T51, there is under development at the present time, a class of cross-country carriers consisting of $\frac{3}{4}$-ton, 4×4 trucks; and $2\frac{1}{2}$-ton, and 5-ton, 6×6 cargo vehicles. The outstanding features of these vehicles are aircooled, horizontally opposed engines, with interchangeable parts, torque converter-planetary gear transmissions and improved suspension systems. Certain special features are being tested on some of these vehicles, such as fuel injection and front and intermediate wheel steering in one of the 5-ton cargo carriers.

Cross-country carriers are envisaged as highly mobile vehicles which would be procured in relatively small quantities for use by front line, mobile troops. The aircooled engine powering this group of vehicles has cylinders, pistons, connecting rods, bearings and other auxiliary parts interchangeable. This is expected to alleviate substantially the parts supply and stocking problems experienced during World War II.

Like the commercial automotive industry, the Ordnance Tank-Automotive Center, Development and Engineering Department, receives requirements from customers which create a substantial number of headaches for design personnel. A few of the performance requirements demanded are:

1. Ability to climb a 60% slope with rated load—this slope, of course, to consist of a natural, unpaved road;

2. A reasonable road speed compatible with the size of a truck. (This means that a truck, regardless of size, will have to be capable of sustained operation at 35 mph or better.);

3. Capable of continuous operation on a 20% side slope;

4. Travel 300 miles at 30 mph without refueling;

5. Ford streams with water up to the driver's neck;

6. Differentials which provide drive to all wheels having traction;

7. Maximum obtainable ground clearance, yet lowest possible silhouette;

8. Ability to operate with flat tires without losing them;

9. Ability to operate at any temperature between -65 F and $+125$ F;

10. Capable of being air-transported.

Fig. 6—The winterization kit includes quilted, fiberglass tarpaulins for the cargo body, insulated floors, and personnel heaters

Furthermore, the Ordnance Corps, which is charged with the maintenance and supply of spare parts for these vehicles, demands a maximum interchangeability of parts and a minimum amount of maintenance. And the Quartermaster Corps, which supplies the fuel, demands a minimum of fuel consumption. In connection with this, new vehicles are designed to operate on 80-octane fuel, but at the same time, they must be capable of operation on 72-octane fuel without harmful effects. This is a nice problem for the design engineer. In addition, it is desirable that the vehicles be so designed as to not need critical materials, and to be capable of volume production at minimum cost.

Manufacturers and the Ordnance Corps have no indication at the time a vehicle is delivered as to just what theater of operation this vehicle will reach. Therefore, use of kits to equip a vehicle for a specific military application results in substantial savings in money and materials. It also makes vehicles far more flexible than if each were required to come from the factory equipped with all accessories.

A deep water fording kit, consisting of intake and exhaust stacks, enables vehicles to negotiate streams with water up to the driver's neck. (See Fig. 5.) And three arctic kits enable vehicles to operate at extremely low temperatures. One is the hard top cab, which consists of an insulated metal cab to replace the standard canvas ones; a personnel heater kit designed to furnish adequate warmth and defrosting at −65 F and a powerplant heater kit which provides standby heat in extremely cold weather. In addition, there are kits of arctic enclosures for cargo bodies consisting largely of quilted, fiberglass tarpaulins, insulated floors and personnel heaters. (See Fig. 6.) For different field operations, various radios are required, and there are a number of radio kits which permit vehicles to be used in any theater. The A-frame kit permits a cargo body vehicle, when it is winch-equipped, to be converted into a wrecker or lifting vehicle. If the vehicle is to be used for towing guns or trailers, there is an electric brake kit which must be used. All vehicles, of course, must be able to take various and sundry machine gun mounts to permit personnel to engage in antiaircraft fire or fire against ground targets, such as are encountered in guerilla territory. To enable uninterrupted supply operations, the standard cab must be replaceable with an armored kit capable of turning small arms fire. And, if the vehicles are to operate in territory which has been mined, they must also be able to take kits which provide protection to personnel.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Diesel Fuel Problems—Storage and Handling

Continued from Page 27

wax crystals comprising the cloud will plug fuel station filters or stop locomotives before the fuel reaches its solid point.

Tank Cleaning

A schedule of tank cleaning and inspection intervals is recommended. It can be based on collection of bottom samples, as is done when sampling tank cars. While the tank is empty it should be inspected for rusting and potential leaks. The rust and scale formation and accumulated water and sediment should be removed. This is usually accomplished by pushing the accumulation to one side of the tank with a stream of water and pumping the sediment out with a portable pump.

Two definite hazards are encountered in cleaning fuel storage tanks: the fire hazard and the asphixiation hazard. The vapor left in the tank after the fuel is removed may be inflammable, and may explode if conditions are favorable. The explosive limits are between 1 and 6% fuel vapor volume in air. Petroleum oil vapors are not considered to be toxic unless large percentages of aromatics are present. Most diesel fuels are free of aromatic hydrocarbons, but those containing large percentages of cracked stocks may have some toxic constituents. There is always danger of asphixiation. Therefore, before any workman enters a tank it should be thoroughly ventilated and tested for explosive atmosphere with suitable instruments. The usual safety precautions of hose mask supplied with external fresh air, safety harness, rope, and observers in attendance outside the tank while the man is in the tank are necessary.

The cost and hazard involved in tank cleaning make it advisable to construct tanks so a minimum of cleaning is required.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price 25¢ to members, 50¢ to nonmembers.)

How to Produce

STEPS and methods used to produce accurate plastic die models were points of major interest at this round table. Also discussed were new processes and materials aimed at improving casting techniques and making plastic models stronger and less subject to internal stress and accompanying warpage.

Panel members pointed out that the chief advantage of plastic die models over wooden models lies in the fact that they are not affected by atmospheric conditions and therefore remain dimensionally stable. Normally overall lateral tolerance of cubed plastic models for an automobile is 0.010 in. at the completion of initial construction. And recent data obtained by checking models which have been in service for two years show an average inaccuracy of only 0.010 in. over lengths greater than 48 in.

Briefly, this process is suggested for producing plastic die models from a clay model:

1. Following management's approval of the full size clay model, the surface on one side of the centerline is built up approximately 1/4 in.;

2. Female plaster molds for both sides of the automobile are begun by applying a thin layer of plaster to the clay model;

3. After the plaster shells set, they are strengthened and tied into a supporting structure by building up the casts with plaster containing manilla or sisal fibers;

4. Plastic models are then cast from these plaster molds. (Only the models cast from the plaster molds made from the untouched side of the clay model are finished at this time);

5. "Hot shot" templates are then made to conform to the refined surfaces of the models;

6. These templates guide the shaping of aluminum templates which, in turn, play two important roles. They are used to finish the plastic models for the second half of the automobile (guide the removal of the 1/4 in. of plastic which resulted from the build up on the clay model) and also to make the "lines-draft."

Versatility of this process indicates the possibility of considerable time savings through careful scheduling during the initial stages of a new program. And coordination of the many phases of a tooling program allows the simultaneous processing of models, checking fixtures, rough iron castings for dies, and so forth.

Accurate plaster molds are a prerequisite to the processing of cast plastic models. Insufficient control is exercised, in some instances, in the processing of plaster molds—with the result that considerable extra work is required to finish the plastic models.

These basic requirements for producing structurally sound and accurate plaster molds evolved from the meeting:

1. A hard plaster such as B-11 Hydrocal which has a low expansion rate and high strength should be used.

2. Recommended proportions of water and plaster

Listening to J. W. Pierce, Renaud Plastics Co., are Moderator R. L. Logue, Kaiser-Frazer, and Secretary J. Richards, Kaiser-Frazer

Plastic Die Models

REPORTED BY

J. W. Richards, Kaiser-Frazer Corp.

• Round Table on Plastic Model Techniques was held at SAE Summer Meeting, French Lick, on June 4, 1951, under the auspices of the SAE Body Activity. Discussion leader was R. L. Logue.

should be used, since excessive water reduces the strength of the finished mold.

3. It is important that the plaster be sifted into the water and, after the mixture has been allowed to set undisturbed from 2 to 5 min, mixing should be carried out until the plaster has thickened or creamed slightly.

4. The mold should be strengthened with manilla or sisal fibers, and it should have a thickness of 1½ to 2 in.

5. Two coats of lacquer, followed by two coats of paste wax, should be applied to the mold surface after it dries.

Many new processes and materials were offered during the discussion, among which the following seem most interesting.

A phenolic form for use as a core material for plastic models was announced. It is cast in the plaster molds and is noncombustible. Density can be controlled and varies from 4 to 40 lb per cu ft. But, at the present time, a density of 13 lb per cu ft is considered desirable. Since the core is expanded from the same material that is used for the surface of the model, temperature changes do not produce internal stress and accompanying warpage.

Models constructed with tubular steel frames are being used and, to date, their dimensional stability has been gratifying. An acid resistant lacquer is applied to the steel frame to prevent corrosion. Compensation for the difference of thermal expansion between the plastic and steel is accomplished by wrapping the steel in fiberglass mats.

One solution to the problem of casting models with thin projecting sections is the inclusion of fiberglass mat fillers. The resulting structure will withstand severe treatment.

Catalysts have been developed to enable the setting of casting resins at room temperature. Tests indicate that physical properties are equal to those obtained with elevated temperature curing. Obviously, the use of these catalysts eliminates the need for curing ovens. The reaction which occurs during setting of the plastic is exothermic. Relative to this, it was announced that the temperature at the interface of the model and mold has been determined. The temperature varies with thickness and ranges from 120 F for castings 1½ in. thick to a maximum of 140 F for castings having thicknesses of 3 in. and greater. This explains why it has been feasible to cast directly on mahogany models without impairing their accuracy.

It is of interest to note that progress has been made toward the development of a casting resin which is free from the corrosive effects usually associated with acid catalyzed resins.

Panel members for this Round Table included (left to right): H. E. Renaud, Renaud Plastics Co.; S. P. Kish, Kish Plastic Products; J. Vitek, American Resin Corp.; W. Stark, H. Stark and Sons; and M. K. Young, U. S. Gypsum

Flying Turboprops

In the Turboliner and XP5Y-1

EXCERPTS FROM PAPER BY

R. C. Loomis, Manager of Inspection and Flight

E. D. Shannon, Chief Pilot

Consolidated Vultee Aircraft Corp.

• Paper "Flight Experience with Turbine Propeller Powered Aircraft" was presented at the SAE National Aeronautic Meeting, New York, April 18, 1951.

EXPERIENCE with two turboprop-powered aircraft—the Convair Turboliner and the XP5Y-1—has demonstrated that the turboprop is an amazingly flexible thrust-producing powerplant. Full forward thrust and full negative thrust are instantaneously available, even with rapid motions of the throttle. When the control system is functioning properly, no surging of power or speed is experienced when the throttle is rapidly advanced. Response to the throttle is immediate and smooth when accelerating for a go-around on a missed approach. This is a pleasant improvement over the reciprocating engine which must be handled rather gingerly when accelerating from a power-off glide.

The basic power section used on both the Turboliner and the XP5Y-1 is an Allison Model 501 turbine. This turbine is geared to a single-rotation four-bladed Aeroproducts propeller on the Turboliner through a 12.5 : 1 gear reduction. Two turbines are united through a single gearbox to drive dual-rotation Aeroproducts three-bladed propellers on the XP5Y-1.

The Model 501 power section includes a 17-stage, single-entry compressor; a set of eight combustion chambers of the cylindrical through-flow type; and a four-stage turbine. The turbine rotor assembly drives the compressor rotor assembly by means of a splined coupling shaft. The power sections in turn drive the reduction gear assembly through splined shafts at the face of the compressor assembly. Each power section incorporates an independent dry-sump oil system as does the reduction gear assembly. In both the XP5Y-1 and the Turboliner, a common oil tank and oil cooler ties the independent oil system into a common unit.

The Aeroproducts propellers are controlled by an electronic governing constant-speed control properly coordinated with the gas turbine fuel control through a single power lever. (The theory of the control was discussed in "New Turboprop Control Uses Fuel-Flow Governor" by George P. Knapp on pp. 57-60 in the April, 1950 SAE Journal.) The electronic governing is used only in the flight range and is designed to give 4-deg-per-sec blade pitch changes for small off-speed signals. Overspeed protection is provided by a hydraulic topping governor which automatically takes over if the electronic governor fails. This governor can change blade pitch angle at a maximum rate of 15 deg per sec. Additional overspeed protection is provided by a droop in the fuel governor which can cut fuel back as much as 50%, depending upon the amount of overspeed.

A single power lever for each power section is installed in the cockpit and operates a coordinating control on the power section. This coordinating control in turn operates the fuel control through an appropriate series of cams and the propeller actuator through a variable potentiometer. The propeller actuator hydraulically controls blade angle in the region below flight governing, but in the flight governing region signals the propeller governing speed through another variable potentiometer which matches actual propeller speed signals from a reduction-gearbox-driven alternator in the electronic governor box. The electronic governor sends signals to a solenoid-controlled hydraulic valve in the propeller control, which in turn changes blade pitch to maintain constant speed. The constant speed is variable from 12,800 rpm turbine speed at operational or flight idle to 14,300 rpm at full power.

Below operational idle, which is approximately 30 deg of throttle quadrant travel, governing ceases and the propeller blade is controlled by the throttle position. At this time, speed is controlled by a fuel governor. Since the governing range must not be

The Convair Turboliner is the first American commercial turboprop transport. It first flew on Dec. 29, 1950. The two-engine Turboliner is a Convair 240 modified to take a commercial version of the Allison XT-40

The U. S. Navy's XP5Y-1 flying boat is powered by four Allison XT-40 turboprops, each developing 5100 bhp plus 800 lb of thrust for take-off. The XP5Y-1 was specifically designed for operation in the roughest kind of weather and water conditions. It requires a turboprop installation with its high power-weight ratio to obtain rapid take-offs in rough water and high-speed performance for evasive action

left while the airplane is in flight, an operational idle stop is provided by the airframe manufacturer which is not to be pulled until the aircraft is on the ground or water-borne. This stop is pulled manually by the pilot on the XP5Y-1 and by an electronic solenoid connected to a switch on the landing gear oleo on the Turboliner. At approximately 15 deg throttle quadrant travel, ground idle or start position is reached. At this point the blade angle for minimum torque and approximately zero static thrust is set and the turbine speed is approximately 11,500 rpm. As the throttle is pulled back below 15 deg, reverse blade angles are set until maximum reverse thrust becomes available at 0 deg throttle quadrant setting. Feathering is provided from any throttle position by driving the propeller actuator electrically to the feather blade-angle position. Manual feathering is available in the event of electric failure by driving the actuator with a manual lever from the cockpit of the Turboliner and a pneumatic actuator from the cockpit of the XP5Y-1.

The operation of a turboprop powerplant is considerably simpler than that of a reciprocating engine. A single power lever combines all the conventional engine controls including throttle, propeller, mixture, supercharger, and carburetor heat. The most important engine instruments required are tachometer, torquemeter, turbine inlet temperature, flowmeter, oil temperature, fuel and oil pressure, and bearing vibration meter. The latter unit has proved to be a valuable indication of incipient power-section failure. In the XP5Y-1, the pilots are provided only with a tachometer and turbine inlet temperature for each engine; however, the turbine inlet temperature will be replaced with a torquemeter since turbine temperature can be limited by the fuel control. The pilot is vitally interested in the power output during take-off and the torquemeter is his only means for determining this since the normal relation of manifold pressure and static rpm is not available as on the reciprocating engine. Turbine inlet temperature is not a true guide of power output.

The flight engineer has a complete set of instruments, but his major concern is to monitor this equipment since adjustments are not normally made

in flight. Normal engine run-up check before take-off is nonexistent because there is nothing to check. Presently [April, 1951] we reset the propeller governing resistance just before take-off, but this will no longer be required when improved controls are installed. The flight engineer monitors turbine inlet temperature, turbine speed, and fuel flow during take-off and advises the pilot only if any of these indications are out of limits.

Engine check-out by ground crews before releasing the airplane for flight is also quite simple in comparison to the conventional engine check-out. This check normally consists of a full-power check of fuel and speed schedules, an overspeed governor check with electronic governing inoperative, an operational idle check of fuel and speed schedules, and a full-reverse check. The whole procedure is accomplished in a matter of a few minutes after bringing the oil temperature up to minimum limits.

Experience to date indicates special design precautions must be taken with turboprops to keep foreign material and water out of the turbines. Several compressors have been severely damaged by foreign material, and we have become very debris conscious. The propellers pick up debris from the ramp and throw it into the inlet ducts. When using reverse on landing the XP5Y-1, the propeller tips throw quantities of water forward which then return through the hub section and on into the inlet ducts. On occasion this water is of sufficient quantity to quench the turbine flame, resulting in a dead engine, after landing. This problem is being solved by adding a plenum chamber to the inlet duct system which is designed to prevent both foreign material and water from reaching the power section.

Starting

Starting the turboprop power sections has proved to be quite simple and rapid. Power is supplied by an Airesearch gas turbine compressor of 35 hp, which is in turn started by an electric motor. The gas turbine compressor starts automatically by throwing a switch and runs with minimum attention from the flight crew. The compressed air drives an air starter mounted on the reduction gear assemblies. This starter spins the power section to 2500 rpm, when ignition occurs. The starter remains engaged until 5500 rpm is reached, at which point the power section is able to accelerate itself to 11,500 rpm. On the Turboliner the propeller turns with the starter, but on the XP5Y-1 the power section only turns and the propeller is engaged later through a hydraulically actuated disc clutch.

Some difficulty was experienced at first matching the gas turbine compressor to the air starter, but minor adjustments solved this problem and starts have been regular and orderly. Minor ducting problems were originally encountered on the XP5Y-1 which required two gas turbine compressors to be operating to get a clean power section start, but these problems have now been solved. No experience with cold weather starting can be obtained in San Diego; however, it is expected that the same cold-weather warming precautions as are followed with reciprocating engines to reduce starting torque will have to be followed with turboprop engines. It is not expected that cold-weather fuel ignition will be a problem. No hot starts have been experienced to date. This is probably due to the excellent fuel control during the starting regime.

Mechanical Experience

The initial taxi runs and early flights of the turboprop airplanes were plagued with all the usual electro-mechanical faults of a brand-new type of engine.

It was soon found that ordinary cannon plugs were not suitable for the turboprop since loose connections immediately resulted in wandering propeller blade angles during taxiing, which prevented the pilot from properly controlling the airplane. After all non-essential cannon plugs were eliminated in favor of straight-through wiring (unfortunately at the expense of easy maintenance) and essential cannon plugs were replaced with vibration-resistant equipment, operation became quite reliable.

Early flights revealed drifting governing speeds due to temperature and pressure changes which changed the electrical resistance of balanced circuits. This condition requires very careful balancing of compensating circuits before each take-off and readjustment of resistors by the flight engineer during flight. Special rheostats were installed for the flight engineer as a temporary expedient to accomplish this adjustment. Redesign of the governing system will eliminate this condition.

It is extremely important that the propeller actuator track the throttle position to an exact schedule within narrow limits. This actuator is operated by an electric motor controlled through variable resistors, called heli-pots, and a micro-positioner circuit using a polarized relay. This type of circuit introduces electrical hysteresis and step changes in the propeller actuator motion which, added to the mechanical hysteresis of the cam operated coordinating control, caused relatively large off-schedule speed signals to be sent to the propeller control. All these conditions are now [April, 1951] being corrected by the installation of a propeller actuator mechanically connected to the coordinating control and by the substitution of fixed resistors for the remaining heli-pots. The latter was made possible by going to single-speed governing.

Difficulty has been experienced in setting the hydraulic overspeed governor. The overspeed governor must start to open below 100% rpm in order to restrict turbine speed absolutely to less than 105% rpm. The result is that the electronic governor is biased at 100% rpm and setting take-off governing speed is a delicate operation. No definite solution has yet been found for this problem, and it may be necessary to get overspeed protection by means of a topping fuel governor.

Fortunately, a complete hydraulic failure in the propeller control has not been experienced. This condition will be dangerous until a mechanical low-pitch stop is installed in the propeller. Such a mechanical stop is mandatory on turboprop installations because of the high drag of the propeller windmilling a turbine at flat blade angles.

Flight Experience

Once the electro-mechanical equipment was operating properly, it quickly became apparent that

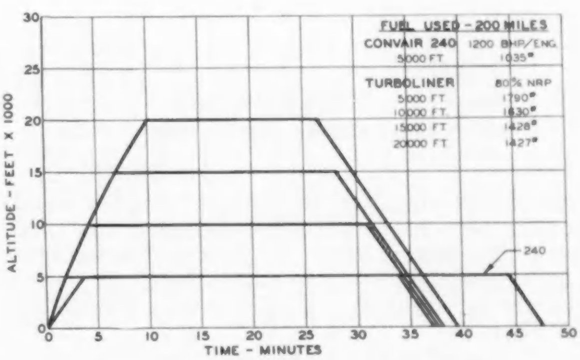
Turboliner versus Convair 240

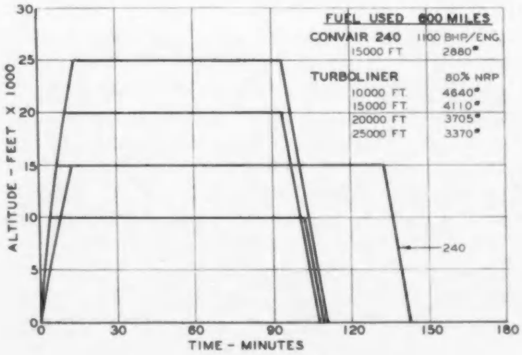
Main advantage of the turboprop is its ability to cruise at substantially higher speeds for the same basic airplane operating weight empty. This speed advantage is just as important on short and medium trip lengths as it is on longer trip lengths. The turboprop can compete with the reciprocating engine to good advantage at altitudes not exceeding 25,000 ft. This is a distinct advantage to airline operators because current thinking is tending more and more to limit maximum cabin differential pressures to 4.5 psi and maximum operating altitudes to 25,000 ft because of the hazards associated with cabin pressure blowouts at higher altitudes and pressures.

	Convair 240	Turboliner (Advanced T-38)
Maximum gross weight, lb	41,790	45,000
Operating empty weight, lb	28,000	28,000[a]
High speed, normal rated power, mph	313 @ 13,500 ft	380 @ 25,000 ft
Maximum cruising speed, mph	272 @ 13,500 ft	345 @ 25,000 ft
Altitude where C.A.R. take-off performance limits maximum gross weight, ft	3,100	Above 7,000
Maximum C.A.R. operating altitude at maximum gross weight, one engine inoperative, ft	5,700	14,000
Required C.A.R. runway length, maximum gross weight at sea level, take-off, ft	4,270	4,030
Required C.A.R. runway length, landing gross weight at sea level, landing gross weight = 41,790, ft	3930 @ 39,800 lb	3900 @ 42,200 lb

[a] Includes increased structural weight for higher gross weight and operating speeds.

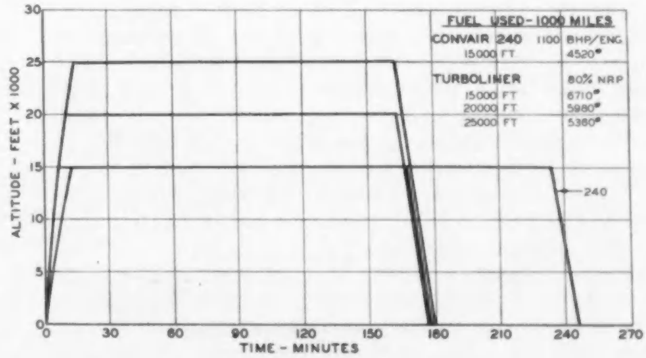
Even for a short haul of 200 miles, the turboprop version saves 10 out of 48 min and carries a substantially higher payload. The best operating altitude is 10,000 ft for the turboprop, and 600 lb more fuel is used. If this fuel is kerosene, which sells for 35% less than 100 octane gasoline, fuel costs are substantially the same. A saving of 10 min on a 200-mile trip may not seem important to the 200-mile passenger, but to the passenger who must take a local for a 2400-mile trip across country and the airline operator who must get maximum utilization out of his equipment, 12 × 10 min, or 2 hr, is very important.





For a 600-mile trip, optimum turboprop cruising altitude is 20,000 ft, where 29 minutes can be saved.

For this trip the fuel cost is less for the Turboliner than the 240.



Restricting maximum operating altitude to 25,000 feet for a 1000-mile trip does not handicap the turboprop. If the fuel reserve is to be 25% of that used for the trip, the turboprop payload is 11,300 lb compared to the 240 payload of 8700 lb.

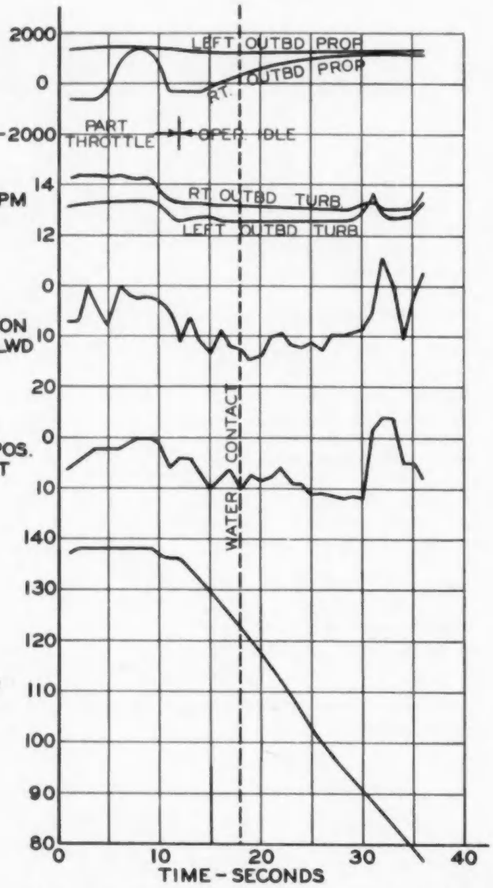


Fig. 1—Effect of a malfunctioning propeller governor on landing

turboprop controls afforded superlative water handling characteristics on the XP5Y-1 during slow speed maneuvering and mooring. During all normal taxiing, up to approximately 40 mph speed, the powerplants are operated below operational idle in the "beta" regime.

In the beta regime, the pilot may readily vary the thrust from each of the four nacelles in small increments. This permits the airplane to be easily stopped dead in water, backed, or turned at will, regardless of wind or tide conditions. It is possible to maintain complete control of the airplane on the water with only two nacelles operating and with these two nacelles on the same side of the airplane. For instance, with only nacelles No. 1 and No. 2 operating, power on No. 2 nacelle is adjusted to make the airplane go either forward or backward as desired and thrust on No. 1 nacelle is adjusted to maintain the desired heading.

A most baffling condition traceable directly to the installation of turboprops on a multiengine airplane came to light on initial landings and stall checks of the XP5Y-1. The airplane developed an almost uncontrollable tendency to yaw and roll when the throttles were reduced to operational idle and the speed was reduced. Fig. 1 shows the sequence of events during a typical landing. Particularly noteworthy is the amount of left rudder and left aileron required to maintain straight and level flight. This plot shows the difference in propeller speed between the outboard nacelles and the resulting difference in thrust between these nacelles. Fig. 2 illustrates vectorially the effect of this condition on the airplane control. The dual rotation propellers probably create abnormal amounts of lift over the wing section behind a thrust-producing propeller and excessive loss of lift behind a drag-producing propeller. This fact is further confirmed during stall tests at operational idle where maximum lift coefficients far higher than calculated have already been observed without yet completely stalling the airplane.

Fig. 3 traces the reason for asymmetric thrust to the fuel schedule required to maintain relatively low turbine speeds at operational idle. The fuel schedule is deliberately designed to prevent the turbine speed from dropping substantially below 90% of rated speed, because at lower speeds acceleration is limited by the surge cam. Thus, when the propeller governor signals for any speed other than 90% at operational idle, substantial changes in power output occur due to the fuel schedule. The effect of these power changes with turbine speed is translated into terms of thrust in Fig. 4. It can be seen from Fig. 4 that if the throttles are reduced to operational idle at a speed of 140 mph in a normal approach and one propeller is governing at 13,120 rpm and the other at 12,600 rpm, there will be an asymmetrical thrust of 8000 lbs due to the normal fuel schedule alone. The turbine speed difference represents only 33 propeller rpm; therefore, the propeller-governing problem can be appreciated.

The fuel schedule between engines is also subject to tolerances. When these tolerances are added to the effect of turbine off-speed, the condition shown in Fig. 1 occurs. In this case, the fuel schedule was fortunately off on the high side on the high-speed turbine, reducing the asymmetric thrust to 1700 lb instead of 8000 lb.

The present design of the propeller provides for a hydraulic low-pitch stop of approximately 9 deg. However, this blade angle is biased by the electronic governor which drives the propeller into a much flatter pitch when the speed is off schedule. As

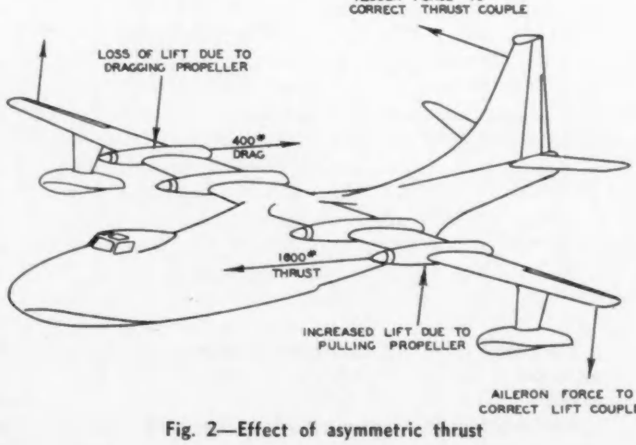


Fig. 2—Effect of asymmetric thrust

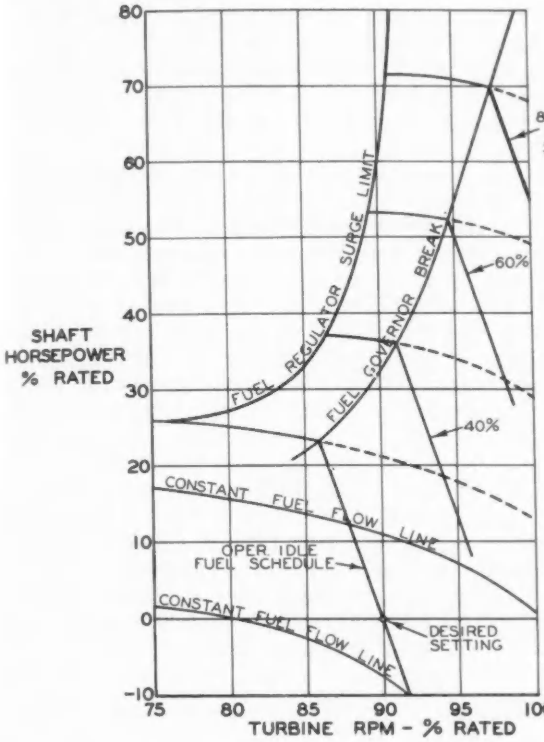


Fig. 3—Typical turbine fuel schedule

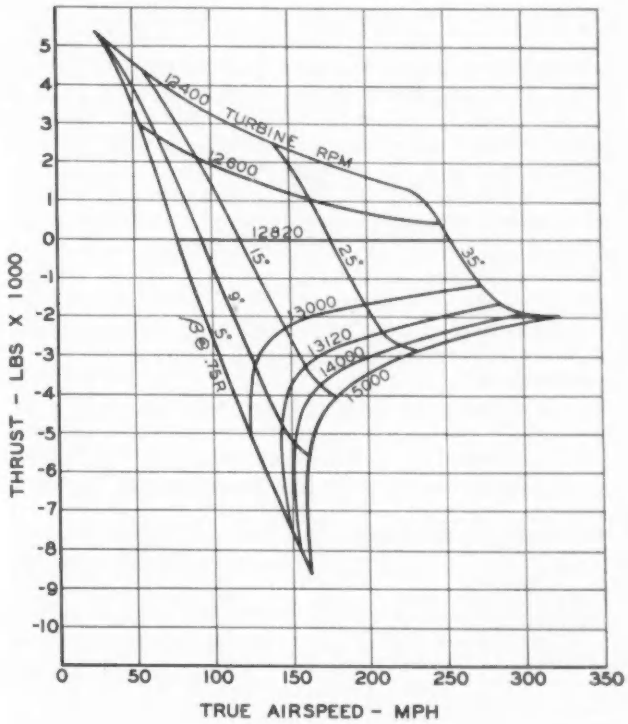


Fig. 4—Effect of turbine speed on thrust at operational idle

can be seen from Fig. 4, this further aggravates the asymmetric thrust problem. If we assume, perfect fuel scheduling for the flight shown in Fig. 1, the right outboard propeller will continue to increase drag as the airspeed drops as shown by following the 13,120 rpm line until 5-deg blade angle is reached. At the same time, the left outboard propeller is producing thrust, as shown by the 12,600 rpm line. Now, if a mechanical stop be added at 15 deg blade angle, the right outboard propeller drag will be limited to 3000 lb at 160 mph, since lower airspeeds will cause turbine speed to drop and drag to be reduced as can be seen by following the 15-deg blade-angle line. At normal touchdown speed of 120 mph, the asymmetric thrust would be 1600 lb if both propellers incorporated a mechanical stop at 15 deg blade angle instead of 6200 lb without the mechanical stop. Of course, this stop would have to be pulled out of the way after touch-down to prevent excessive thrust from building up at low speeds.

It is obvious that propeller synchronization would materially assist the asymmetric thrust problem. Synchronization will be incorporated at an early date and should materially alleviate the asymmetric thrust problem. Any synchronizer, however, will probably be unable to cope with large off-speed signals of a malfunctioning propeller governor; a mechanical low-pitch stop remains mandatory.

Another approach to the asymmetric thrust problem is to schedule 100% turbine speed for operational idle, and eliminate the droop characteristic of the fuel governor since it would no longer be needed at high turbine speeds. Referring again to Fig. 3, if the fuel control metered a constant fuel

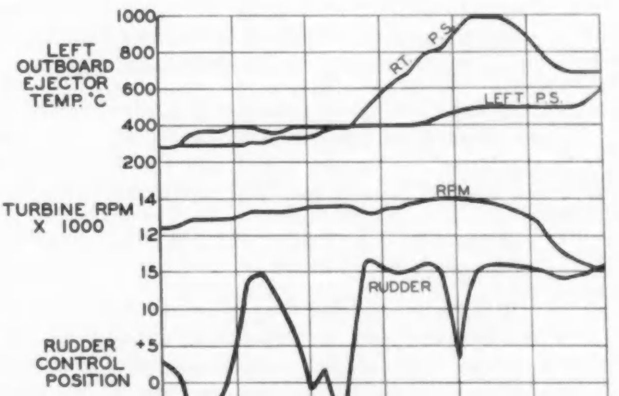


Fig. 5—Effect of turbine burn-out at take-off

flow at operational idle, regardless of turbine speed, and the propeller governed at 100% rpm, the normal characteristics of the turbine would increase horsepower if turbine speed tended to drop below 100%. This increased horsepower would, therefore, prevent turbine speed from dropping too low and would give the same protection against low turbine speeds as the droop-type governor gives. Thus, the same difference in governing speed gives one-third the difference in horsepower and, therefore, one-third the asymmetric thrust. Furthermore, the variable resistors in the propeller control circuit can be replaced with fixed resistors (because turbine speed is constant at 100% during all flight conditions), and speed control becomes much simpler and more reliable.

The single-speed system described above is now [April, 1951] being installed on the XP5Y-1, as well as synchronization, and we are confident that this new schedule will largely eliminate the asymmetric thrust problems.

The hazardous nature of a turbine burn-out was pointedly brought out on one attempted take-off of the XP5Y-1. Just before the aircraft was ready to become airborne, it took a violent swerve to the left and the left wing pontoon dropped into the water. The take-off was aborted, and it then became apparent that something was wrong in the left outboard nacelle. This propeller was feathered, stopped and the aircraft returned to its moorings. Examination showed the turbine wheel to be completely burned out in the left power section of the left outboard nacelle.

Fig. 5 describes graphically the sequence of events during this take-off. The heading remained constant at 98 deg until hump speed was reached about 13 sec after advancing throttles. Rudder oscillation was normal up to that point to maintain a straight course. An 8 deg turn to the left was experienced going over the hump, which while unusual did not cause alarm because a quartering wind was blowing. This was corrected by rudder application and a new heading of 90 deg was maintained. Then the aircraft veered to the left at about 80 mph and the throttles were all pulled back at the 29 sec point when it became apparent that the left turn was becoming uncontrollable. From the ejector temperature record, it can be seen that the left outboard engine started to fail at exactly the time the first veer to the left was experienced. Turbine speed was not affected until the second veer to the left

Continued on Page 52

The Authors' Conclusions on Turboprop Installations:

● **The problem of keeping turboprop shaft torque within reasonable limits has been solved in recent installations by coordinating the power and speed controls through a single lever and limiting the propeller-blade-angle change rate in the normal operating range. Excessive torques are prevented from occurring at feathering by simultaneously feathering the propeller and shutting off fuel to the turbine.**

● **Excellent thrust response characteristics throughout the entire range from full reverse to full take-off power have been obtained by means of electronic valving of the propeller hydraulic control and coordination of propeller speed with the turbine power schedule. Hunting and surging of speed and torque experienced in early turboprop installations have been eliminated in recent installations.**

● **Starting a turboprop has become a simple and rapid operation as a result of using an air-motor starter powered by bleed air from the compressor section of a small auxiliary free-running turbine.**

● **High windmilling drag is an inherent characteristic of turboprop powerplants. Such drag becomes very hazardous when encountered during take-off or landing. Practical turboprops must therefore incorporate a completely reliable propeller auto-feathering device which is usable for both take-off and landing regimes. In addition, mechanical low-pitch blade angle stops must be incorporated for the in-flight operating conditions.**

● **Turboprops use reduction-gear ratios as high as 15 : 1 and at the same time require turbine speed control accuracy of approximately ± 50 rpm in 10,000 rpm, or a total tolerance of 1%. Thus, propeller governors must be very accurate and reliable if satisfactory flight characteristics are to be achieved. Propeller speed synchronization is a mandatory requirement on multiengine aircraft.**

● **Asymmetric thrust on multiengine turboprop aircraft can become excessive during throttled landing approaches and results from the high idle speeds required for turbine acceleration. This condition should be corrected by incorporating positive mechanical low-pitch blade angle stops in the propeller, synchronizing propeller speeds, and coordinating fuel and propeller-speed schedules so that large changes in power output do not occur for small changes in turbine speed.**

● **Compressor blade damage from foreign material, turbine burner quench-out from water, and compressor blade icing possibilities all require that special attention be paid to the air entrance ducting on turboprop engines.**

ISTC Division VIII Reports on

BORON STEELS

EDITED BY

Harry B. Knowlton, Chairman of ISTC Division VIII—Boron Steels and Supervisor, Materials Engineering, International Harvester Co.

INVESTIGATION of boron steels for carburizing has rightly focused considerable attention on the case hardenability and the effect of boron on the properties of the case. As a quantitative approach to this problem, some users have made carburized Jominy end-quench tests to determine the hardenability for various carbon concentrations. In making such tests great care must be exercised to determine carbon concentration accurately. Additional carburized end-quench results for several steels are reported by users in this article; however, the effect of boron in the case of carburized steels is not yet clearly defined. Jominy end-quench results can be used to good advantage if correlated with production heat-treating conditions by determining the Jominy distance and carbon concentration which corresponds to critical areas on the production carburized and quenched part.

An additional report of satisfactory fatigue testing of carburized boron-steel gears is included in this article. In some cases of heavy-section carburized gears made from the lower alloy boron steels, however, some have reported insufficient case hardenability at the surface. Excessive distortion during heat-treatment of certain designs of carburized gears has also been reported by some users. Some reports have indicated that boron steels may be more satisfactory for carburized gears subject to failure by pitting at the pitchline than for gears subject to failure by bending fatigue at the root surface.

In the heat-treating grades the outlook for the use of boron steels is very bright, as indicated by reports herein on bolts, axles, springs, and chains.

Third in Boron Series

THIS is the third in a series of articles on boron steels based on information submitted by steel producers and users to Division VIII—Boron Steels of the Iron and Steel Technical Committee. The history of boron steels, pertinent metallurgical principles, and some specific examples of the application of both carburizing and heat-treating grades were covered in the first two articles.

The present article includes further information on carburizing and heat-treating grades of boron steels. Further evidence is presented to indicate that the boron-steel heat-treating grades (0.30-0.65% carbon) can readily be substituted for higher alloy steels in bolts, springs, axles, and similar parts. The application of boron steels for carburizing is more complicated, however, and more data and experience will be required before a clear evaluation can be made.

Carburizing Grades

Data on 14B18

From F. F. Vaughn of Caterpillar

The hardenability of the case and core of one sample of 14B18 steel was determined by making a carburized end-quench test.

The curve marked "A" in Fig. 1 represents a 1¼-in. round pack carburized at 1680 F whose carburized case was removed in machining to specimen dimensions. Case depth was 1.2–1.5 mm.

The other curves represent another specimen finish machined, pack carburized at 1680 F, and after

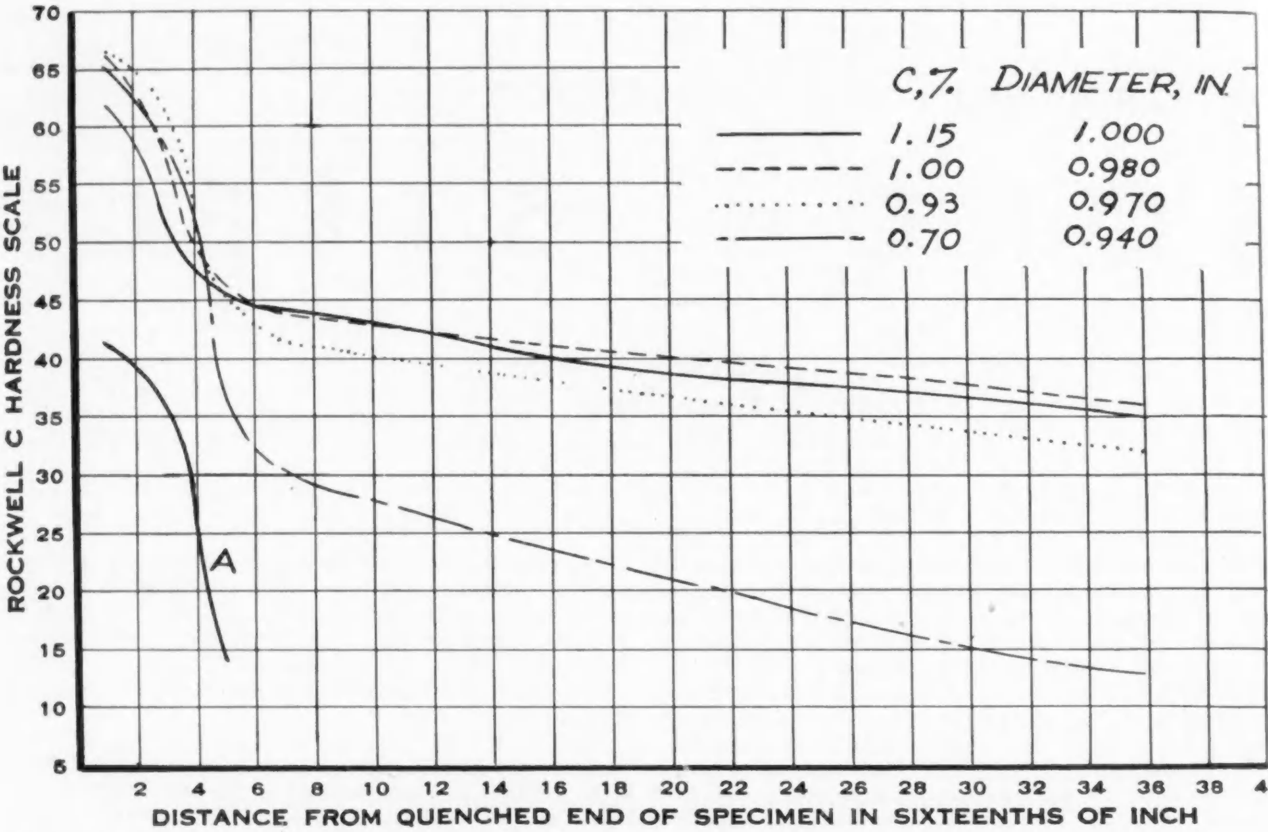


Fig. 1—End-quench test data on 14B18, heat T 0018, of grain size 5-8. Composition was 0.18% C, 0.83% Mn, 0.014% P, 0.032% S, 0.21% Si, 0.10% Ni, 0.05% Cr, 0.03 Mo, 0.0007% B

hardening ground to and tested at diameters and carbon concentrations indicated.

It will be noted that the case hardenability up to approximately 4 sixteenths was slightly higher for the 0.93% carbon level than for 0.70, 1.00, or 1.10% carbon.

—June 26, 1951

Data on SAE 9420 and 94B20 From W. E. Jominy of Chrysler

Fig. 2 shows hardenability curves for the SAE 9420 steel without boron treatment. This is for comparison with the steel of similar type with boron treatment shown in Fig. 3. (Fig. 3 is the same as Fig. 5 of the first installment of this series of articles, on page 21 of the August SAE Journal.)

The SAE 9420 steel is lower in chromium and manganese content, and therefore should be somewhat lower in hardenability than the steel in Fig. 3, even though it had no boron treatment. However, there is no question that the boron-treated steel, 94B20, has much higher hardenability in the case than the SAE 9420.

Also, the surface of this steel, like the boron-treated steel, shows less hardness and less hardenability than the steel at 0.015 and 0.025 in. below the surface. This I believe is due to the presence of austenite. I subjected the hardenability bar to cold treatment at −90 F, which should convert some of the austenite to martensite. Fig. 4 shows that this occurred and that both the hardness and the hardenability of the surface layer were greatly improved on this SAE 9420 steel by cold treatment.

When the carbon content is high in the surface layer, I have found it possible to increase the hardness and hardenability of these layers in boron-treated alloy steel by cold treatment.

—June 20, 1951

Data on 4118, 41B18, 50B20, and 8617 From Frank Sailer of International Harvester

Hardness of these steels was measured at the surface and 0.015 in. below the surface of a specimen carburized at 1700 F to a depth of 0.035–0.045 in., pot cooled to 1600 F, and end quenched with a 2½-in. spray of 75 F water.

Table 1 shows the analyses of the specimens. Figs. 5 and 6 show the hardnesses found.

—June 8, 1951

Table 1—Chemical Contents

Steel	ASTM Grain Size	Mn	Si	Ni	Cr	Mo	P	S
		Chemical Content, %						
8617	8	0.79	0.24	0.68	0.51	0.24	0.012	0.029
4118	8	0.82	0.22	0.28	0.55	0.13	0.012	0.029
50B20	8	0.88	0.23	0.22	0.48	Nil	0.030	0.037
41B18	9	0.90	0.25	0.22	0.45	0.15	0.019	0.034

Data on 80B20 from R. H. Lundquist of Minneapolis-Moline

A sample of a single heat of 80B20 was used in this test. Analysis showed this heat to have 0.19% carbon, 0.65% manganese, 0.024% phosphorus, 0.030% sulfur, 0.31% silicon, 0.33% nickel, 0.23% chromium, 0.14% molybdenum, and 0.0012% boron. Grain size was 7.

A 3-in. hot-rolled bar was turned down to 2⅞-in. diameter; a 1-in. hole was drilled lengthwise in the bar; and "doughnuts" of 1½, 1, and ¾ in. length were cut for test pieces.

Two pieces of each size were pack carburized to 0.040-in. case depth. One piece of each size was oil quenched direct from the carburizing temperature, 1675 F. One piece of each size was cooled in the pack and reheated in salt to 1550 F and oil quenched. Table 2 shows the hardness measurements.

We believe on the basis of these very limited tests on a single heat that 80B20 holds promise as an acceptable substitute for 8620 H when carburized

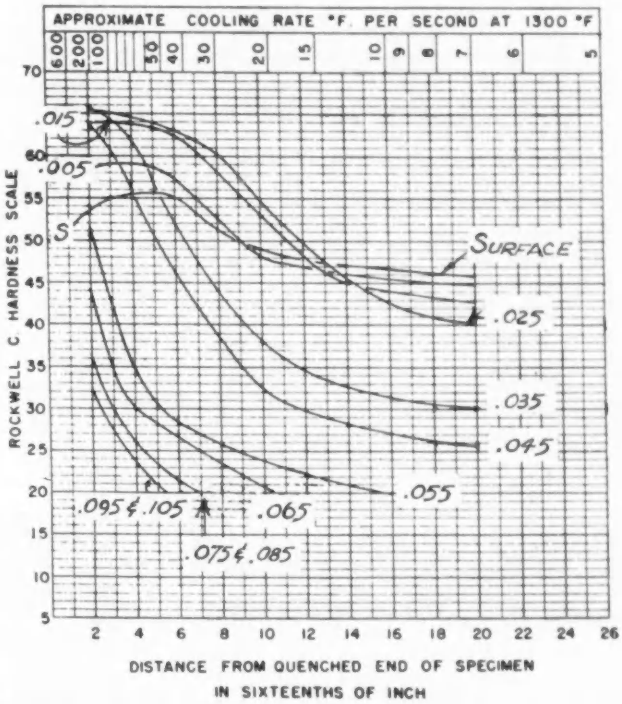


Fig. 2—End-quench test data on 9420, heat 83181, of grain size 7-8, box carburized at 1720 F for 8 hr and end-quenched. Composition was 0.20% C, 0.73% Mn, 0.016% P, 0.029% S, 0.25% Si, 0.40% Ni, 0.30% Cr, 0.11% Mo. Carbon contents at various depths below the surface were:

in.	% C	in.	% C
Surface	...	0.055	0.56
0.005	1.02	0.065	0.44
0.015	1.04	0.075	0.32
0.025	0.96	0.085	0.25
0.035	0.81	0.095	0.23
0.045	0.65	0.105	0.20

Fig. 3—End-quench test data on 94B20, heat 44725, of grain size 6-8, box carburized at 1700 F for 8 hr and end quenched. Composition was 0.20% C, 0.85% Mn, 0.018% P, 0.021% S, 0.27% Si, 0.36% Ni, 0.44% Cr, 0.12% Mo. Carbon contents at various depths below the surface were:

in.	% C	in.	% C
surface	1.03	0.050	0.47
0.010	0.97	0.060	0.37
0.020	0.86	0.070	0.31
0.030	0.73	0.080	0.28
0.040	0.59		

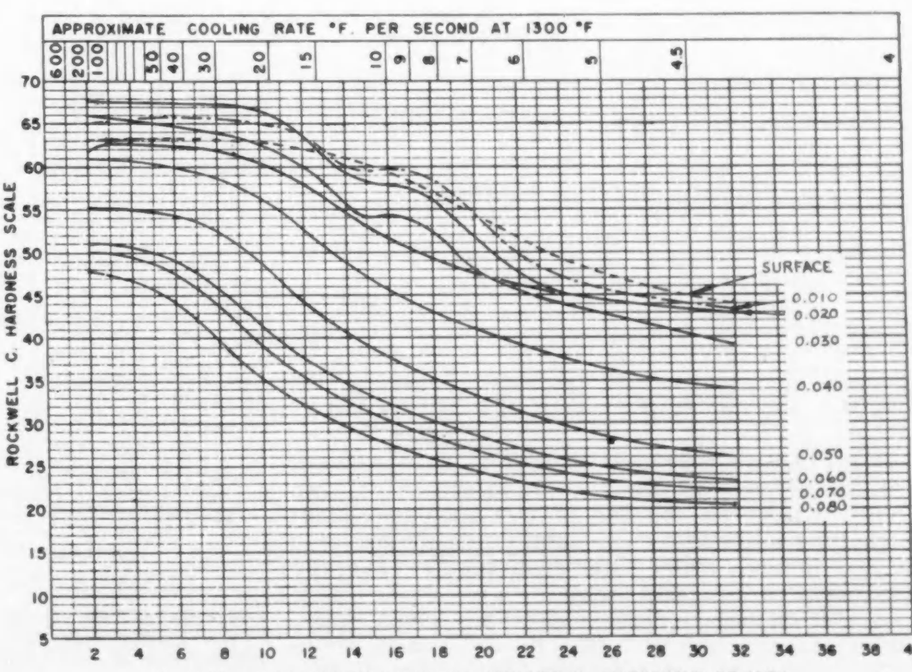


Table 2—Hardnesses Measured on Specimen of 80B20

	Direct Quench Hardness, Rc	Reheat & Quench Hardness, Rc
1½ in. Length		
case hardness	64-64.5	39-61
core hardness—¼ in. from surface	27-28	16-19
1 in. Length		
case hardness	65.5-66.5	36-43
core hardness —center of section	26-28	18-19
¾ in. Length		
case hardness	65-66	44-45
core hardness —center of section	33-34	16-17

and quenched from the pot. We will not consider it for use when reheat and quench is necessary until more experimental work has been done to prove it satisfactory for that type of heat-treatment.

—June 7, 1951

Data on 80B20

From S. L. Widrig of Spicer

A comparison of fatigue tests of 80B20 test gears with average results of previous tests on similar 8620 gears is shown in Tables 3 and 4. The results indicate that the 80B20 gears tested would be satisfactory for the application, and that the martempered gears are definitely superior to the conventional quenched and tempered gears.

—June 8, 1951

Heat-Treating Grades

Data on Boron Steels

From J. E. Tschopp of Chicago Screw Co.

Since 1939 we have used between 20,000 and 25,000 tons of boron steel for the manufacture of high quality capscrews for one of our customers. Oil quenching is employed on nominal diameters 7/16 in. and smaller, while water quenching is generally used on sizes 1 in. and larger.

[Water-quenched carbon steel has given satisfactory results in the 7/16-1 in. size range. The carbon steels are less expensive than boron steels—for which steel mills charge alloy steel rates. Besides, it is difficult to control the hardness of 14B35 in this size range, because oil quenches do not give enough hardness for some heats and water quenches give too much hardness.]

Where boron steels are used, we find the center hardness of the as-quenched specimens to average better than Rockwell C 45 and surface hardness will run in the neighborhood of 52-55. A minimum tensile strength of 145,000 psi is maintained at Rockwell C 30.

We find that the boron-treated 1035 type of steel —that is, 14B35—machines and cold heads very similarly to regular SAE 1035. We would like to point out, however, that the use of the boron-type steel over previously used alloy grades has resulted in a very distinct saving in tool costs with improved machinability rates.

—April 30, 1951

Data on 50B40, 50B50, and 42B60

From M. C. Kester, Frank Sailer, and C. Parish of International Harvester

Alloy steel bolts are being made in production from boron steels at West Pullman Works of the International Harvester Co. to the following specifications: 135,000 psi minimum yield strength; 150,000

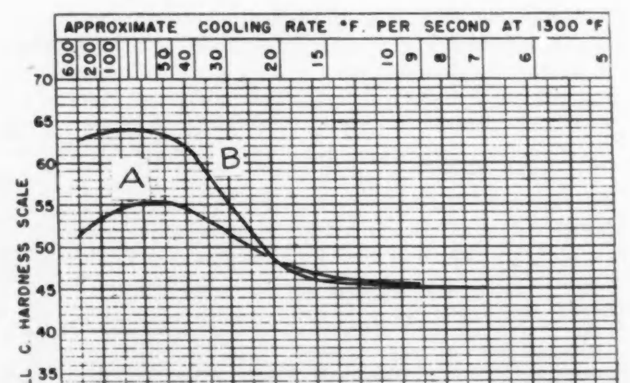


Fig. 4—End-quench test data on 9420, heat 83181. Specimen A was box carburized at 1720 F for 8 hr and end quenched. Specimen B was box carburized at 1720 F for 8 hr, end quenched, and cooled to −90 F. Hardness was taken on the surface

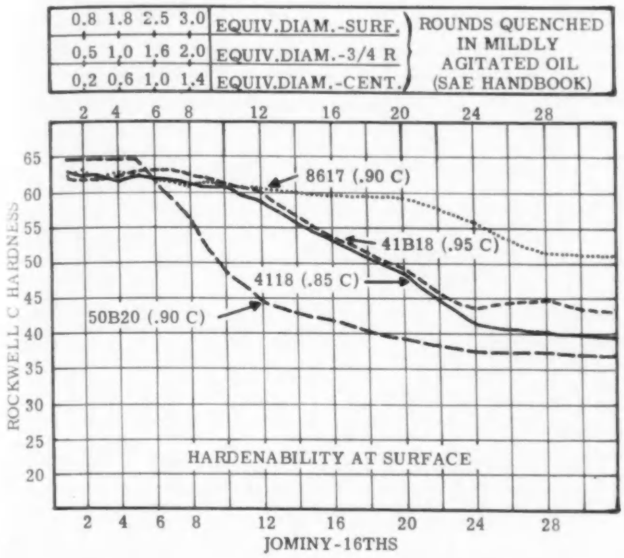


Fig. 5—Carburized hardenability of 4118, 41B18, 50B20, and SAE 8617 steels at the surface. Specimens were carburized at 1700 F to a depth of 0.035-0.045 in., pot cooled to 1600 F, and end quenched with a 2½-in. fountain of 75 F water

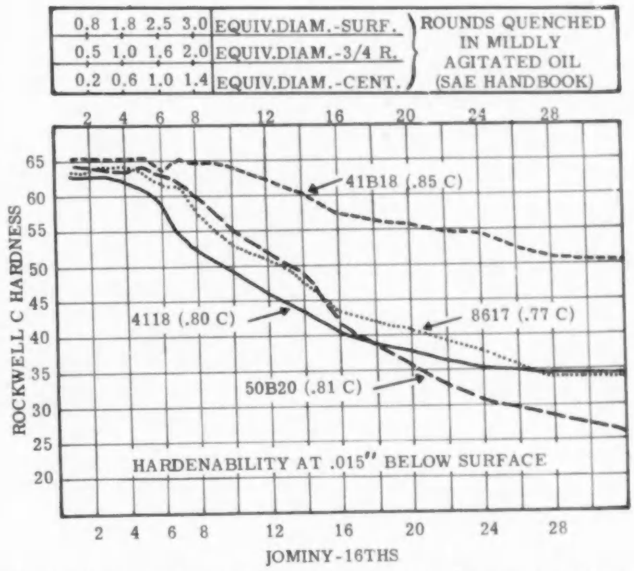


Fig. 6—Carburized hardenability of 4118, 41B18, 50B20, and SAE 8617 steels at a depth of 0.015 in. below the surface. Treatment was same as that for specimens of Fig. 5

Table 3—Results of Fatigue Tests on 80B20[a] Test Gears

Carburizing Cycle	Quench[b]	% C in first 0.005 in.	Depth of Case to 50 Rc, in.	Core Hardness at Pitch Line, Rc	Cycles at 2200 rpm and Indicated Load in psi of Face Width[c]		
					4960 psi	5460 psi	5960 psi
Carburized at 1700 F Cooled to 1550 F	Oil	0.84	0.045	41	582,000 Failure	———	———
Carburized simultaneously with above gear set	Modified Martemper at 400 F	0.84	0.044	41	1,000,000	(This load accidentally omitted)	294,000 Failure
Carburized at 1700 F Cooled to 1150 F Reheated to 1550 F	Oil	1.01	0.051	43	414,000 Failure	———	———
Carburized simultaneously with above gear set	Modified Martemper at 400 F	1.01	0.049	38	1,000,000	1,000,000	615,500 Failure

[a] Republic Heat 45128: C = 0.19%, Mn = 0.62%, Ni = 0.32%, Cr = 0.30%, Mo = 0.13%, Si = 0.29%, B = 0.001%.
[b] All gears drawn at 340 F after quenching.
[c] Loads were increased in 500-lb increments after each 1,000,000 cycles.

Table 4—Results of Fatigue Tests on SAE 8620 Gears

Carburizing Cycle	Quench[a]	% C in first 0.005 in.	Depth of Case to 50 Rc, in.	Core Hardness at Pitch Line, Rc	Cycles at 220 rpm and Indicated Load in psi of Face Width[b]		
					4960 psi	5460 psi	5960 psi
Carburized at 1700 F Carburized at 1700 F	Oil	0.80 to 1.05	0.040 to 0.050	38 to 43	405,000 Failure	———	———
Carburized at 1700 F Cooled to 1550 F	Modified Martemper at 400 F	0.80 to 1.05	0.040 to 0.050	37 to 41	1,000,000	1,000,000	9,600 Failure
Carburized at 1700 F Cooled to 1150 F Reheated to 1550 F	Oil	0.95 to 1.20	0.040 to 0.050	37 to 42	320,000 Failure	———	———

[a] All gears drawn at 340 F after quenching.
[b] Loads were increased in 500-lb increments after each 1,000,000 cycles.

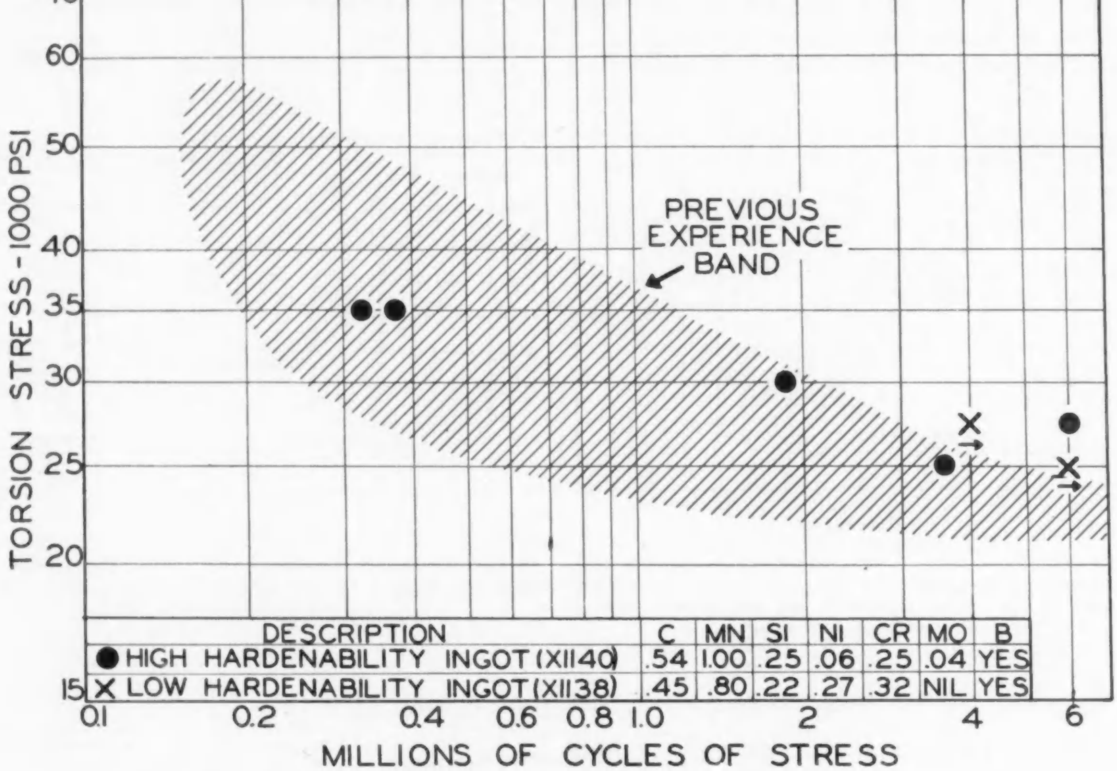


Fig. 7—Torsion fatigue tests on Farmall M rear axle of 50B47 steel

psi minimum tensile strength; Rockwell C 45 minimum at center of threaded section as oil quenched; Rockwell C 32—38 after draw at 800 F minimum. The boron steels now used and the original steels are as follows: 50B40 replacing 4037 and 4042 on bolts up to 5/8 in., inclusive; 50B44 replacing 8637 on bolts over 5/8 to 1 in., inclusive; 50B50 replacing 8640 on bolts over 1 in.

Two lots of 50B47 steel representing relatively low and high hardenability were fabricated into tractor axles, which were heat-treated for a surface hardness of 321—388 Bhn. The results of torsion fatigue tests on these axles are shown in Fig. 7. (Fig. 7 is the same as Fig. 5 of the second installment of this series on page 58 of the September SAE Journal.) The shaded area represents previous experience with several types of steel and a large number of axles. It will be noted that the experimental data for the new axle shafts fall in or above the previous experience band. The critical section of this type of axle is a spline section 2.75 in. in diameter. Failures usually occur in the spline section.

Crawler tractor equalizer leaf springs ($6 \times 1\frac{1}{2}$-in. cross-section) were made of 42B60 steel by Standard Steel Spring Co. These springs were superior in surface quality to the regular 9262 H steel, and proved satisfactory from the standpoint of fabricating and heat-treating and engineering road tests.

—May 2, 1951

Data on 81B45 from B. L. Johnson, Jr. and W. E. Day, Jr. of Mack Manufacturing

Four bars, 2½ in. in diameter by 5 ft long, of 81B45 steel were received for test purposes from Bethlehem (Lackawanna Heat 3L074). The mill analysis of this heat was: 0.43% carbon, 0.80% manganese, 0.015% phosphorus, 0.020% sulfur, 0.26% silicon, 0.36% nickel, 0.45% chromium, and 0.13% molybdenum.

Rear axle shafts were machined from one of the bars and tested in static torsion after oil quenching from 1600 F and tempering at 750 F. A similar shaft made from 4150 H steel oil quenched from 1550 F and tempered at 750 F was tested for comparison. The result of these tests is shown in Fig. 8, the shear stress being plotted as a function of total angular deflection. Both shafts failed in the body section with a shear break perpendicular to the axis of the shaft. The maximum shear stress was about the same for both steels but the 81B45 exhibited considerably more ductility, having a total angular deflection about twice as great as the 4150 shaft.

Hardness of the 81B45 shaft was 477 Bhn at the surface, 450 at a depth of 3/16 in., 401 at 9/16 in., and 357 at the center. Hardness of the 4150 H shaft was 477 Bhn at the surface, 441 at a depth of 3/16 in., 420 at 9/16, and 412 at the center.

One of the 2½ in. diameter bars was forged down

to 1½ in. diameter and then normalized at 1600 F. End-quench hardenability tests were run on the forged bar at two different quenching temperatures, 1650 and 1550 F. The plot of the hardenability data showed no difference in hardenability for the two quenching temperatures up to a distance of ½ in. However, beyond ½ in. the bar quenched from 1650 F shows somewhat higher hardness.

Tensile tests and Charpy V-notch impact tests were made on specimens machined from the forged and normalized bar. These specimens were oil quenched from 1600 F and tempered for 2 hr at different temperatures ranging from 600 F to 1200 F. The test results indicated that the steel responded in a normal manner to the various heat-treatments.

—May 11, 1951

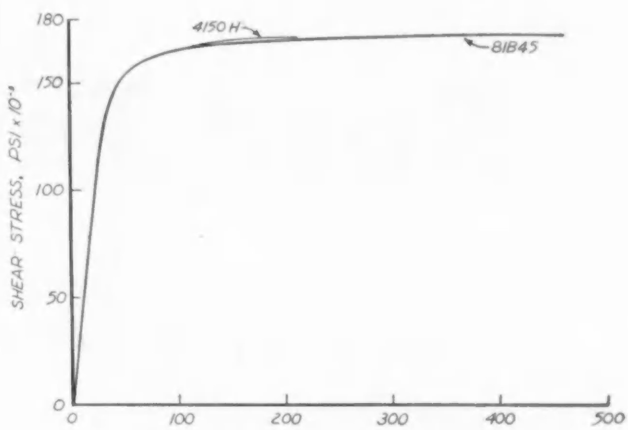


Fig. 8—Static torsion tests of rear axle shafts

Data on 81B40 and 81B45

From P. K. Zimmerman of Ryerson

Fig. 9 shows hardenability data on 81B40 steel. Analysis of this US Steel Heat 104794 was 0.40% carbon, 0.85% manganese, 0.020% phosphorous, 0.023% sulfur, 0.27% silicon, 0.33% nickel, 0.48% chromium, 0.13% molybednum, and 0.0011% boron.

Fig. 10 shows hardenability data on 81B45 steel. Analysis of this Bethlehem Steel Heat 3L074 was 0.43% carbon, 0.80% manganese, 0.015% phosphorous, 0.020% sulfur, 0.26% silicon, 0.36% nickel, 0.45% chromium, and 0.13% molybdenum.

Austenitizing temperature for both steels was 1550 F.

—June 8, 1951

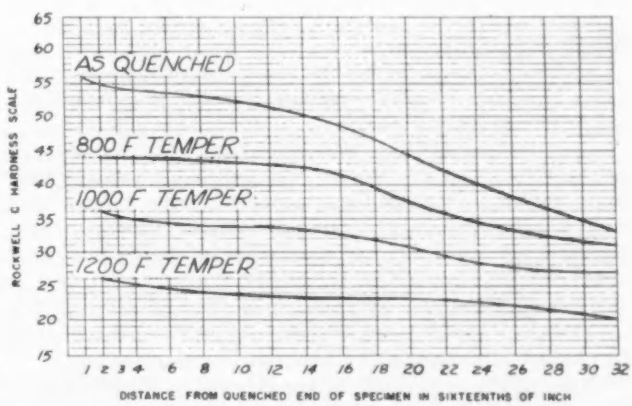


Fig. 9—Hardenability data on 81B40 steel. Austenitizing temperature was 1550 F

Data on NE94T22

From N. E. Henderickson

During World War II, I was responsible for the manufacture of heat-treated anchor chains made of NE94T22 steel, Grainal treated, for aircraft carriers and cruisers. I was able to through-harden sections of 2¼- and 2½-in. diameter, with water quenching. Incidentally, these were resistance-flash-welded chains, and therefore a higher carbon content could not be tolerated for fear of air-hardening. Fortunately, the Grainal addition gave ample hardenability, and not a single link out of the many thousands made, showed flaws or cracks from air-hardening or quenching stresses.

—June 9, 1951

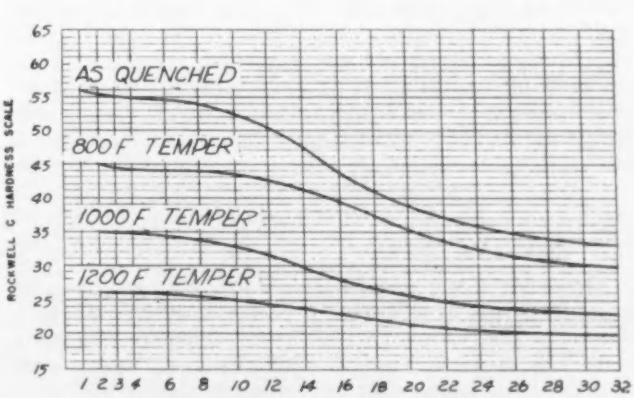


Fig. 10—Hardenability data on 81B45 steel. Austenitizing temperature was 1550 F

Road Testing Cars—

Basic Performance Testing

BASED ON PAPER BY

R. W. Gaines, Ford Motor Co.

THE proving ground or testing department, set up as part of an engineering organization, serves two basic functions:

- It carries out testing work at the request of other departments.
- It conducts a basic testing program, both on its own and competitive products, which serves as a base for reference purposes.

The first obligation requires that the testing department maintain a crew of competent test drivers, mechanics, and engineers; and adequate, up-to-date instrumentation and test procedures. The second requires the maintenance of a complete fleet of test cars, both company and competition.

A specific series of test programs is set up for these cars. They include not only performance tests but also basic durability tests and static tests.

Durability tests are run for a total of 20,000 miles. Performance tests are conducted at the beginning, midpoint, and end of this schedule. In addition to performance data, cost data and wear measurements are accumulated so that conclusions as to total running costs, maintenance costs, operating (fuel, oil, tires) costs, tire wear rates, brake wear rates, and so forth, can be reached. Static tests include such items as body dimensions, comparative visability measurements, suspension ride and roll rates, center of gravity locations, and so forth.

Many performance tests are made but these three will be discussed in some detail because of their significance in determining the basic performance of a car:

1. Fuel economy.
2. Acceleration.
3. Road load power.

There is no one way in which fuel economy can be measured which will give a completely satisfactory answer. Therefore, four different types of economy tests are run as a matter of routine. Each test represents a particular set of operating conditions which the car owner can and does encounter.

The first, and perhaps the most precise method of testing, is the so-called specific fuel economy test. Volumetric measurement of fuel consumption is

Continued on Page 50

Special Problem Road Testing

BASED ON PAPER BY

R. W. Burton, Cadillac Motor Car Division, GMC

INSTRUMENTATION plays a very important role in special problem road testing. It is, however, not the only means of obtaining a solution. More often than not a problem can be solved by merely driving or riding the automobile and observing the results of various changes.

"Seat of the Pants" road testing is used extensively in ride development work. Here, the primary interest is how the car feels to the passengers after a change is made, rather than the mechanics behind the change. Similarly, development of a steering mechanism can best be evaluated by simply driving the car over various types of roads under different conditions.

While this method of road testing is very convenient and is used to a great extent, it has certain drawbacks; namely, lack of calibration and record. If a problem is complex and it becomes necessary to determine the mechanics behind it, then instruments are used.

Instrumentation does not have to be complex, in fact, the simpler the better. Complex instrumentation not only takes considerable time to set up, but often gets so involved that the orginal problem is lost in a lot of meaningless data.

The most useful of all road testing instruments is the recording oscillograph. (See Fig. 1.) This permits phenomena to be recorded which are too faint or minute to be observed by eye. Two general types are used—direct writing and photographic recording. Both are capable of multi-channel recording, which makes them extremely useful for simultaneous study of different but related phenomena.

The recording oscillograph in itself is of no value without proper pick-ups or transducers. (A transducer is a device which converts a physical phenomena into a proportional electrical voltage for amplification and/or recording.) The problem of selecting the proper transducer depends upon the characteristics of the transducer, the recorder, the amplifier, as well as the particular application. Numerous pick-ups are commercially available. These can be used to detect such phenomena as displacement, vibration, acceleration, speed, torque, pres-

Continued on Page 51

Types, Problems, Instruments

Endurance Road Testing

BASED ON PAPER BY

H. Paul Bruns, Chrysler Corp.

A NEW part or product must be subjected to a rigorous endurance test before it can be released to production and sold to the public. Obviously such a test must be more severe than the operation to which the part will be subjected under normal service conditions. Many specific types of endurance tests are used by automobile manufacturers.

Endurance testing on rough gravel roads serves as a final check on such components as frame, suspension, drive train, steering system and body structure. The procedure calls for 10,000 miles at speeds below 45 mph. A thorough inspection of the test cars is made at least once, sometimes twice, a day to catch impending failures. Any repairs necessary in the interest of safety are made.

After completion of 10,000 miles, the vehicles are returned to the home base for disassembly and careful inspection for failures and minute cracks. Zyglo or magnaflux equipment is used to search out hidden cracks. Results of such tests are then forwarded to the personnel responsible for these various items to aid in the improvement of their design.

It is desirable to determine to what extent air cleaners, oil filters, breather caps, and so forth, are subjected to dust and their capacity to withstand dust attacks.

Cars are sent to areas where dust conditions prevail and run on selected dusty gravel roads for up to 16 hr per day. The filters on test are checked periodically to determine the amount of dust collected and also to judge whether or not their filtering characteristics have been impared. For a bench mark by which to compare the production and experimental filters on test, a car incorporating nearly 100% perfect filters accompanies the group.

Certain chassis and body components must be protected against dust and dirt. Therefore, such items as brakes, tie rod seals, and door and window dust seals are also tested.

Field locations are also selected for studying the effect of high temperatures on vehicle components. Among the most important tests are those involving the engine cooling system. Heat rejection, fan efficiency, thermostat operation, and other cooling problems are carefully worked out in these hot regions.

Most automotive manufacturing concerns utilize a cold testing laboratory for investigation of starting and warm-up characteristics of engines. Cold room work is supplemented by field testing in cold areas.

Vulnerability of the ignition system to excessive water either from heavy rain, moisture condensation or running through water puddles is tested. Vehicles are run through water at varying speeds and motion pictures taken which show water entry into the engine compartment. Corrective measures consist of redesigning splash flaps and improving the ignition waterproofing. Ignition systems are further checked by subjecting the engine to a heavy stream of water from a hose.

Vehicles must be tested and proved in mountainous regions. Generally speaking, the roads traveled are smooth pavement—the object being not to break up structural members but rather to study fatigue and wear. Major parts tested include steering, axle assemblies, transmissions, brakes and power plants. The cars are loaded heavily with ballast and driven at moderate speeds on the most twisting, winding roads to be found in this country. Tests are run with various transmission ratios, both up and down hill. If brakes are of primary interest in the test work, low gears are not used for coasting.

Tires are tested in locales throughout the country where hot conditions prevail and where high speeds can be maintained. For comparison tests, four different make cars are equipped with tires manufactured by each of the major rubber companies. Each car carries a certain make tire on the left front wheel at the beginning of the test and a different make of tire on each of the other wheels. After a predetermined number of miles, the tires are rotated on each car. This rotation continues until the tires are worn; after which, measurements are made to determine tread wear in miles per thousandth of an inch. Different makes of cars are used to cancel out the effect of different chassis designs.

Other tire tests run include tire squeal, tire tramp, tire temperatures, effect of wheel alignment on tire wear, blowout investigations, tire pressure build up, and effect of tire tread shape on wear.

* Papers, "Basic Performance Testing" by R. W. Gaines, "Special Problem Road Testing" by R. W. Burton, and "Endurance Road Testing" by H. Paul Bruns, were presented at the Road Testing Panel held at Detroit Section Junior Activity Meeting on Feb. 26, 1951. This panel is available in full in multlithographed form from SAE Special Publications Department. Price: 25¢ to SAE members; 50¢ to nonmembers.

Basic Performance Testing—continued

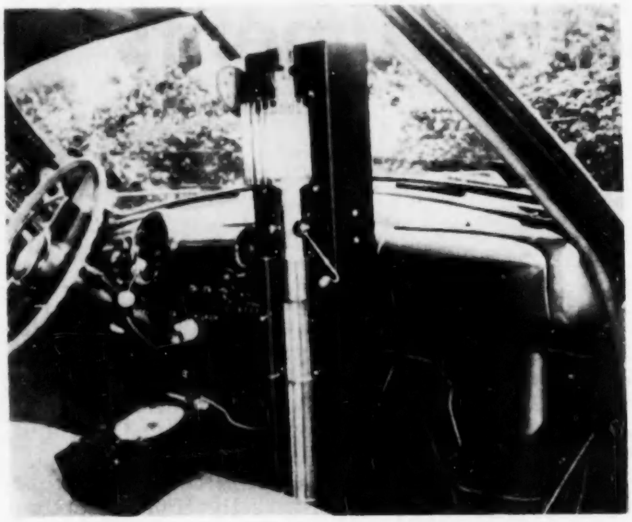


Fig. 1—Volumetric measurement of fuel consumption is made by means of a graduated burette in the specific fuel economy test

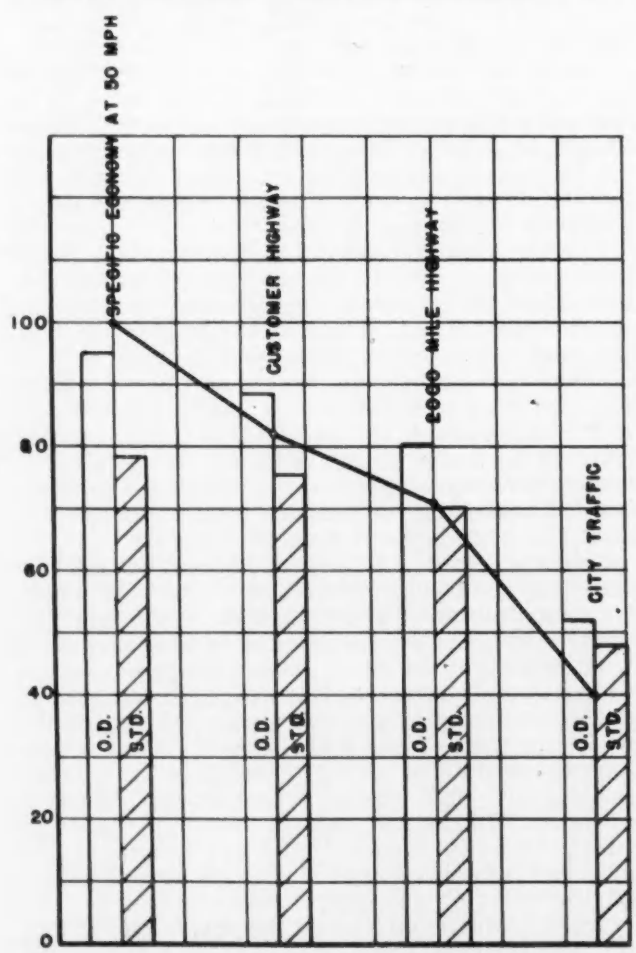


Fig. 2—Illustration of the value of running four types of fuel economy tests

made by means of a graduated burette, interposed in the engine fuel system, while the car is being operated at a fixed speed over a measured distance. (See Fig. 1.) The data so obtained are useful in forming an idea of what economy should be expected at a particular constant speed.

The second type of fuel test is a 2000 mile run, conducted on an outside highway route composed of both gravel and hard surfaced roads. In general, speeds approximate the maximum safe speeds which can be maintained on the particular roads involved, with the average speed about 50 mph. Brake retards are stipulated at all cross-roads and maximum deceleration stops are specified at certain legal stop intersections. This test represents a rather severe condition as far as obtaining good fuel economy is concerned.

A more representative check is obtained with the customer highway fuel economy test. A public highway route composed of 100% hard surfaced roads is used, with round trip distance about 410 miles. Cruising speed and top speed are held to 60 mph and stops, brake retards and accelerations are made only as traffic and legal conditions require. These test conditions simulate average customer usage.

The fourth test employed is the city traffic test. This endeavors to duplicate customer usage where nearly all operation is obtained under city traffic conditions.

The value of running all four types of economy tests is illustrated by a comparison between cars of the same make and model but equipped with different type transmissions. (One car has a standard 3-speed transmission and the second, an overdrive unit.) The advantage offered by the overdrive varies, depending on the type of operation. (See Fig. 2.)

A second basic performance measurement is acceleration, or in customer's usage, "pick-up." For routine tests, a stop watch board is used in conjunction with a fifth wheel. Stop watches time successive speed intervals during an acceleration run so that the average acceleration can be determined for each interval. The fifth wheel indicates the end of a speed interval, stopping one watch and starting the next. A series of readings is obtained from which average accelerations for each of a series of consecutive speed intervals can be obtained.

An even briefer method of gauging acceleration is the time required to run from a standing start to a specified speed, going through the gears and shifting at the optimum points. The speed range generally used is from 0 to 60 mph. This method is particularly useful as a means for gaining a rough comparison of cars using different types of transmissions.

In the event that a more detailed study is required, acceleration records using torque meter and recording oscillograph are also made. These records reveal transient conditions which cannot otherwise be determined, such as clutch chatter, fluid coupling cavitation, and drive line wrap-up.

One of the parameters determining car perform-

nce is the road load power requirement. This presents the power required for the car to overcome wind resistance, rolling friction, and tire losses at any given speed. Tests to determine this quantity are run by using a torque wheel mounted in place of one of the standard rear wheels. (See Fig. 3.) Torque requirements at the rear wheel for any road load speed are recorded directly by an oscillograph. Car speed and wheel rpm are also recorded on this instrument. From these data, it is possible to construct the road load power and torque curves.

Road load power curves for a group of 1949 model cars, see **Fig. 4**, shows a considerable spread in road load power requirement. The road load power curve has importance because of its bearing on both fuel economy and acceleration. Within the limits of styling requirements, some improvement in performance can be obtained by designing the car so as to provide less work for the engine to do.

Fig. 3—Tests to determine road load power requirement are run by using a torque wheel mounted in place of one of the standard rear wheels

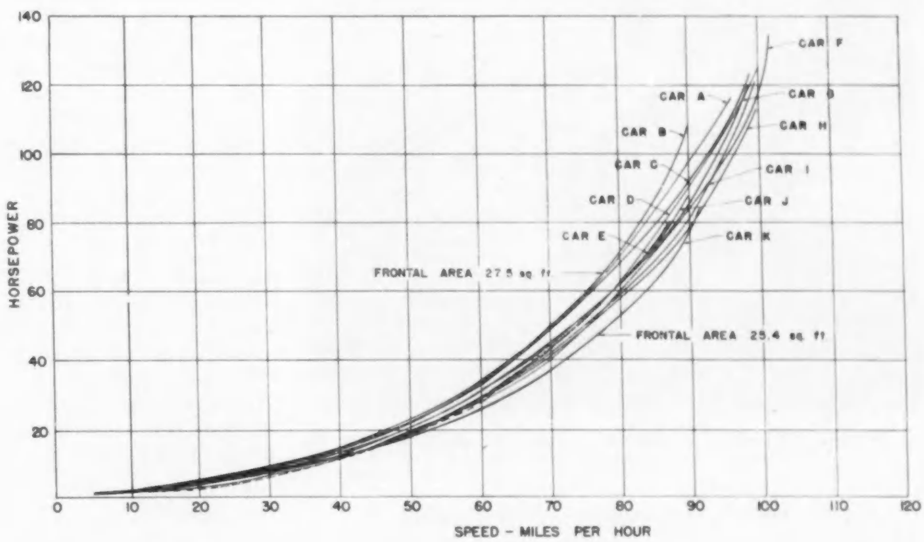


Fig. 4—Road load power curves for a group of 1949 model cars show a considerable spread in road load power requirement

Special Problem Road Testing—continued

sure or temperature.

The tape or wire recorder and the noise analyzer are extremely useful when working on noise problems such as body boom or road rumble. A multiple-channel recording potentiometer is often used in heater development and warm-up problems.

A remote reading spark indicator is used on engine work when developing the spark advance curve or during the determination of road octane number. With this indicator the operator is able to set the spark to any predetermined advance and then observe the engine characteristics.

A torque wheel permits measuring rolling resistance or available power directly at the wheel, without having to correct for the inefficiencies of such parts as the trasmission or differential. When more accuracy is required, two torque wheels can be used to give a summation of both rear wheels in case the division of torque by the differential is not equal;

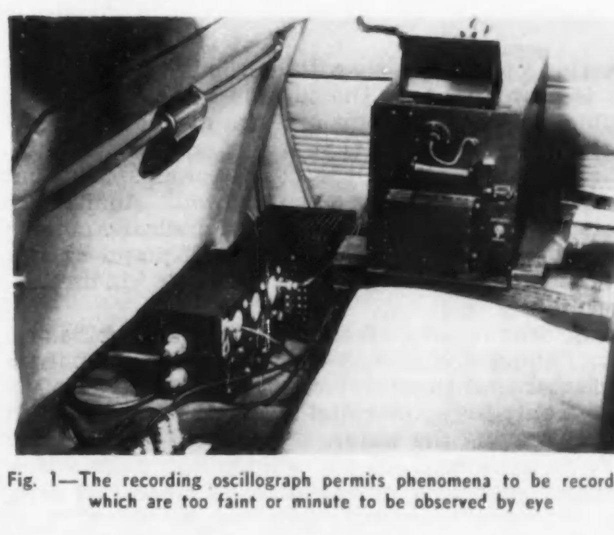


Fig. 1—The recording oscillograph permits phenomena to be recorded which are too faint or minute to be observed by eye

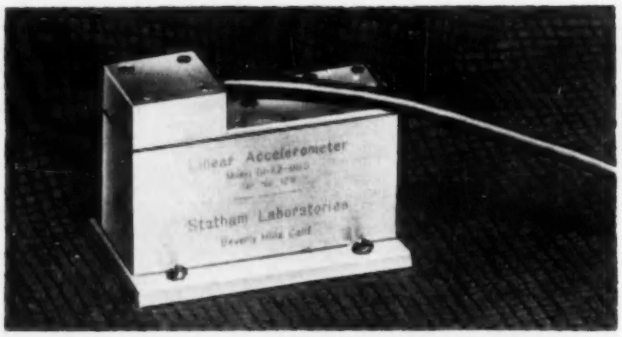


Fig. 2—The accelerometer is used extensively in brake work and for performance tests

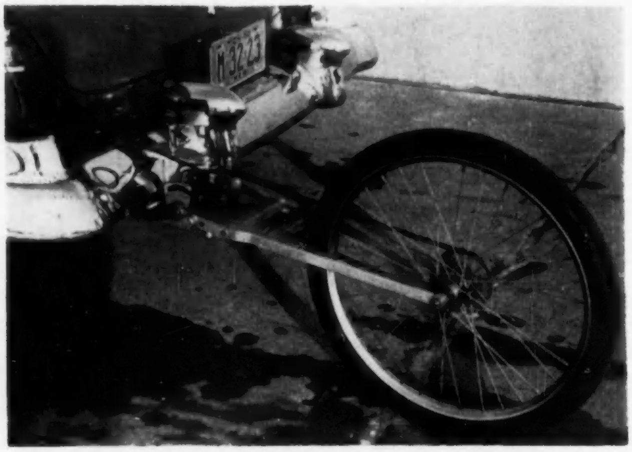


Fig. 3—The fifth wheel is used to indicate car speed and can be equipped to measure distance traveled

torque wheels can also be used to determine the braking effect of each individual wheel.

The accelerometer, shown in Fig. 2, is used extensively in brake work and for performance tests. It must be fastened securely to the car, the level section of the trunk floor being a very convenient place. Its operation is simply the displacement of a sprung mass due to the force of acceleration. The displacement is detected by strain gages and can be read on a meter or recorded on an oscillograph.

A fifth wheel is used to indicate car speed. (See Fig. 3.) It is merely an accurately calibrated d-c generator, the output of which can be used to record speed on an oscillograph. Distance can be recorded provided the fifth wheel is equipped with contact points which will produce an electrical impulse at predetermined intervals.

Sometimes it becomes necessary when working on a particular problem to operate the vehicle at conditions other than road load. A long steady hill of the required grade would be ideal but is often difficult to find. This problem is solved by using a tow dynamometer which makes it possible to hold the vehicle to any speed, at any load greater than road load. The tow dynamometer is used to a great extent on cooling tests where the vehicle speed must be held down for long periods of time while checking cooling system efficiencies.

A discussion on road testing would not be complete without mention of the chassis dynamometer. This is not exactly a piece of road testing equipment, but it is a very important link between the laboratory and the road. Many problems which involve the complete vehicle can best be studied on the chassis dynamometer. It provides testers with an opportunity for close observation, especially on the underside of the vehicle. However, even though a solution to a problem is obtained on a chassis dynamometer, it must still be tested on the road before final acceptance.

Flying Turboprops in the Turboliner and XP5Y-1

Continued from Page 40

started simultaneously with a drop in turbine speed. It is presumed that the turbine wheel burned out completely at this point and the drag of the compressor was so great that it not only absorbed all the horsepower from the other power section but dragged the propeller down as well. Analysis of the propeller speed and airspeed indicates that a burned out turbine wheel at take-off power creates as much or more drag than a propeller windmilling both power sections.

The drag resulting from a burned out turbine or a windmilling engine has caused concern. Analysis indicates that the best technique during take-off is to use only 80% power and attain 120 mph airspeed before leaving the water.

It is considered that a windmilling engine is a distinct possibility during take-off since fuel failure can be experienced. Windmilling is a distinct possibility during landing from either fuel failure or flame-out at the low powers used during approach. We have already demonstrated that turbine burn-out can occur during take-off. It, therefore, becomes mandatory that all turboprop installations incorporate a simple, foolproof, and 100% reliable auto-feathering system for both take-off and landing conditions. It is believed that the best means of achieving this is to install a reliable torquemeter which will sense negative torque and automatically initiate a propeller feathering signal whenever negative torque occurs.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Helicopters—New Vehicle For Local Service Operations

BASED ON PAPER BY

N. E. Rowe, British European Airways

• Paper, "Helicopters Applied To Local Air Service Operation—British Experience And Requirements," was presented at SAE National Aeronautic Meeting, New York, April 17, 1951.

NEW fields are opening up for helicopters. Experimental work being carried out by British European Airways demonstrates the capabilities and vast potential of helicopters as a new vehicle for local service airline use. Operation in the British Isles of a regularly scheduled helicopter passenger service and successfully flown night-mail schedules under instrument conditions bear strong witness to the future potentialities of this aircraft.

Formed for the purpose of learning about helicopter operations in Great Britain and Europe, the experimental program was initiated in July of 1947 by the acquisition of three Sikorsky S-51's and two Bell 47B's. Selection of these machines was made for two reasons. It made operational potential as flexible as possible and also permitted gaining experience with widely different types of helicopters.

A study showed some of the cities and towns of the British Isles that could be included in a helicopter route system. (See Fig. 1.) Only two places shown on the map have a population less than 110,000. The 50 and 100 mile circles struck from the capital and the great centers of industry illustrate the ranges involved.

The longest desirable direct link is that between Manchester and Glasgow, a distance of 183 miles. But the average of the existing strong commercial links is 67 miles and the average between the ten largest places is 85 miles. These ranges are too small to be economical for fixed-wing aircraft. Likewise, the advantage of such transit over existing surface transport is small when account is taken of the time and inconvenience of getting to the airport. An essential requirement for any short-haul aircraft is transit from one city center to another, with complete regularity of service. A helicopter equipped with these qualities clearly has immense potentialities for use in the British Isles. This is the spur to B.E.A.'s efforts and sets the pattern for development.

At its inception in June of 1950, the Welsh operation, between Cardiff and Liverpool (with an on-

REQUIREMENTS for the helicopter as a new vehicle of transport are becoming quite definite as a result of various operations carried on for the past few years. The aircraft must:

1. be multi-engined

2. be capable of operation from an into rotor-stations with alighting areas of 200 × 200 ft (at a steady approach path of 45 deg to the horizontal in still air)

3. have castoring undercarriages or other means to permit sideways movement on the ground

4. have rotor blades that can be folded and spread expeditiously on the ground in conditions of high wind (up to 52 mph)

5. be provided with anti-icing or de-icing means for power plants, aerodynamic lifting and control surfaces, and cockpit glazing

6. meet rigid standards of stability and control; and structural vibration and noise level (internal and external) limits

7. be capable of carrying 25-35 passengers at a cruising speed of 140-150 mph

Need for a high rate of utilization requires that maintenance time on the ground be kept to a minimum. Parts should be removable and replaceable at known lives, rather than overhauled, in periods which least interfere with earning power.

Fig. 1—Some of the cities and towns in the British Isles that could be included in a helicopter route system

demand stop at Wrexham), was the first regularly scheduled helicopter passenger service to be run anywhere in the world. It is still being run as a daily return service. During the summer months, two return trips were run per day, the on-demand stop at Wrexham being introduced on July 1.

A detail of the route is shown in Fig. 2. The air distance is 142 miles and the scheduled elapsed times Cardiff-Liverpool and Liverpool-Cardiff are 1 hr 55 min and 2 hr, respectively. As a point of interest, the best train time is 5½ hr. The operation was approved by the Ministry of Civil Aviation for visual contact conditions limited by cloud ceiling of not less than 500 ft and horizontal visibility not less than ½ mile. Blind flying instruments were not carried.

The route passes over high ground about 55 miles south of Liverpool (800–1000 ft) and about 15 miles from Cardiff (400 ft). It was not possible to obtain weather reports along the route in advance, but operational results indicated a great need for such information. During the four summer months June, July, August, and September, when the daily return schedule for each terminal was being operated, the regularity of service was 96.5%. Cancellations were: 15 due to weather (despite a very poor summer); 12, low cloud; 2, low visibility; and 1, headwinds. This was considered a reasonably satisfactory result.

A feature of special interest is the system of progressive maintenance devised to maintain the scheduled flying hours (eight hours per day, six days per week) with only two aircraft. Essentially this involved breaking down Check 2 (25 hr) and Check 3 (100 hr) so that a part of each could be done during Check 1 (5 hr). The method included the replacement of parts at stated lives.

In practice, progressive maintenance proved very successful. Protracted periods of standing time for maintenance were avoided, and reserve aircraft were nearly always available. Only once in 408 scheduled trips was the service interrupted due to mechanical fault. This confirmed the high opinion held of the mechanical reliability of the S-51.

Operationally, the summer service was a success and many valuable lessons were learned, particularly from passenger comment cards. Certain major trends in passenger reaction were established. But it should be remembered that they represent the views of passengers who flew mostly for reasons of necessity—not because they were interested in the helicopter.

1. Passengers flew to save time and because the mode of travel was comfortable. The fare, however, was considered to be high.

2. The major proportion of passengers said they

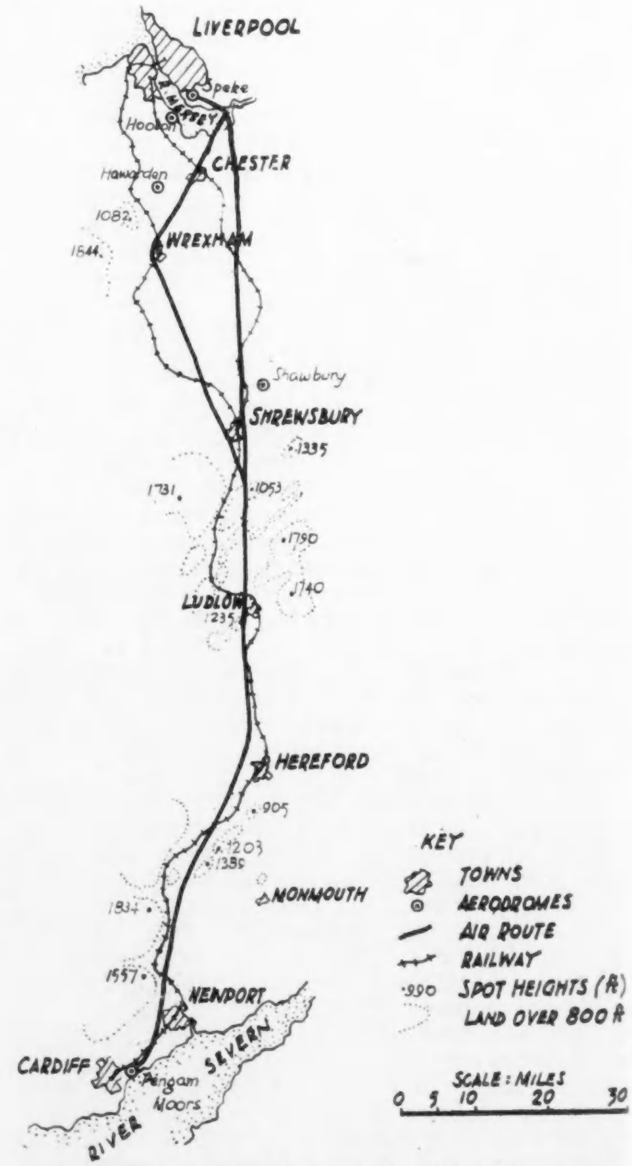


Fig. 2—Detailed route of the first regularly scheduled helicopter passenger service to be run anywhere in the world

uld always use the helicopter on this route.

3. Helicopter travel was considered to be very ractive because of its "informality," the wonderful w which it afforded, the feeling of safety it im- ed, and the close association with the pilot.

4. A high proportion of passengers complained out vibration and noise in the first two months. this time, the aircraft were overhauled and rutally no further complaints were made.

5. Passengers found the accommodation cramped, he cabin drafty and badly ventilated, and com- plained about the lack of a lavatory. They also disliked the forward sloping floor.

Winter operation on the Welsh service suffered from weather conditions, mainly low visibility. On one occasion, in a heavy storm, snow on the windshield prevented the pilot from completing the journey.

In considering the economics of this first helicopter passenger service, one must remember that it is an experiment. With only three seats to sell in a 450 hp machine, a low utilization rate (650 hr per year per aircraft), and use of a non-streamlined vehicle, the airline could not be expected to make money. In fact, with fares at normal rates and low load factors, revenue was only a very small percentage of total costs. But, for what they are worth, here are the figures:

Total costs per revenue flying hour	$106.65
Hourly cruising costs per revenue flying hour	35.00
Take-off and landing costs per revenue landing	5.30
Costs per capacity passenger mile	.40

The broad significance of these figures is that the special qualities of the helicopter will not be obtained cheaply, and therefore economies must be sought (1) in maintenance, (2) by running at the maximum possible utilization, and (3) by raising cruising speeds.

The interest of the British Post Office in the helicopter led to a number of important developments. They sought information on regularity and punctuality, and naturally were interested in the economics. Also, since the main movement of mail in Great Britain is by night, they wanted to know how the helicopter would perform on a night service. This stimulus encouraged and supported B.E.A.'s desires and intentions to press on into the comparatively unexplored field of blind flying in helicopters. Principal program objectives were (1) to give pilots practice in technique required, and (2) to develop arrangements of instruments, navigational aids, and so on, which would be adequate for safe and regular operation under instrument conditions (excluding blind landings and take-offs).

For experimental purposes, the rear passenger compartment of the S-51 was completely curtained with black material, and a blind flying, dual control, instrument arrangement installed. (See Fig. 3.) To prevent undue vibration of the instruments, particularly important in blind flying, the instrument panel was flexibly mounted. (See Fig. 4.) The artificial horizon was provided with adjustable pitch and roll datum lines and increased sensitivity. The pilot being trained flew in the rear location, with a safety pilot in the normal forward position. Intercommunication was by voice pipe.

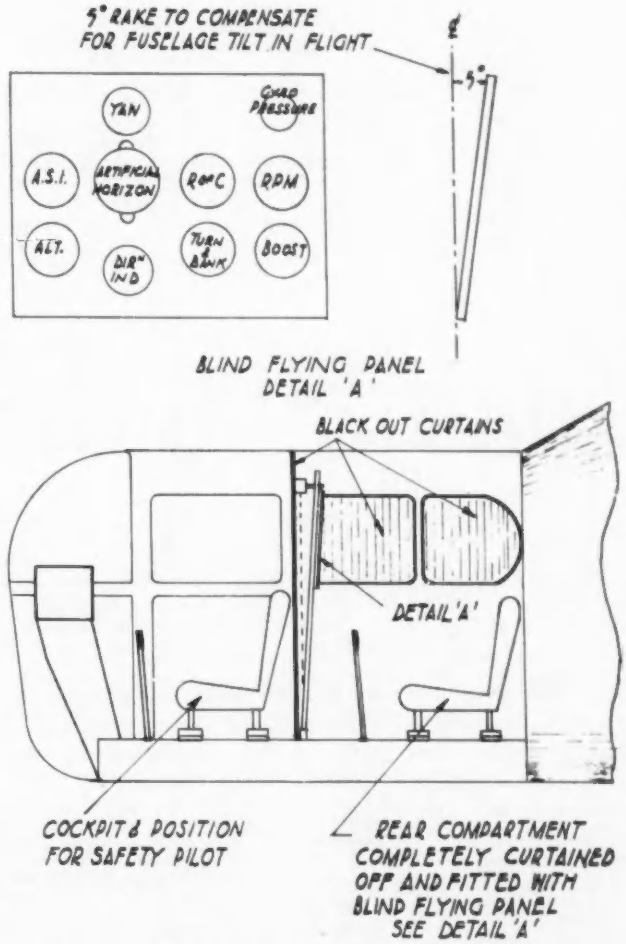


Fig. 3—Arrangement used to give pilots practice in the technique required for blind flying

The preliminary flying with these arrangements demonstrated that when flying blind:

1. It is possible to control the S-51 under all flight conditions associated with normal speeds, including rough air conditions.

2. The pilot is fully occupied in controlling the aircraft; therefore, information for navigation must be presented in such a form as to be ready for immediate use.

3. The artificial horizon is the primary instrument.

4. The yawmeter is not necessary.

5. Grouping and positioning of instruments is important to minimize pilot fatigue.

The next step in the program was instrument flying from the pilot's normal position. Fig. 5 shows the instruments added for this purpose. Cloud flying done with this set-up included all normal maneuvers and flying in slightly rough air. The pilots found it easier to fly blind from the front seat than from the rear one. (No doubt because they are further from the center of gravity in this position and therefore more responsive to angular accelerations in the pitching plane.)

Prior to commencement of regular operations under instrument flight rule conditions, practice flying was done in simulated conditions of difficulty

or emergency such as:

1. Violet aerodynamic upsets throughout the speed range.
2. Failure of the gyroscopic instruments.
3. Engine failure.

The pilot in the blacked-out rear cockpit could cope with all the emergencies except failure of the artificial horizon. However, with considerable practice it was found possbile, although difficult, to fly straight and level in very calm air by using the cross level in conjunction with the direction indicator. These results were encouraging and, combined with growing experience in cloud flying, provided satisfactory evidence on which a Certificate of Airworthiness for blind flying was granted in October, 1949. This enabled the unit to undertake a scheduled night mail operation between Norwich and Peterborough (67 miles) over the period Oct. 17, 1949 to April 15, 1950.

The route passed over sparsely inhabited country which gave little assistance in the form of ground lights, particularly in the early hours of the morning. Consequently, even when not in cloud, the pilot was often flying blind because he had no ground reference. Of the 222 hr of flying done, slightly over 80 were under completely blind conditions, partly in cloud. A regularity of 77% was achieved, with weather accounting for nearly all of the irregularity (12% due to low cloud, 8% to fog, and 2% to high winds). The residue was the result of radio and mechanical faults.

One of the limitations of operation was a cloud ceiling of 500 ft over local terrain. This condition arose out of consideration of emergency landing in the event of engine failure. Flying was done at an average height of about 700 ft and conditions were fairly typical of an English winter. On about half the flights, winds were greater than 30 mph and on 6%, greater than 41 mph. At such times the air was very rough and the pilot became extremely tired, since the controls in the S-51 are manually operated and heavy.

Only once was severe icing encountered. Then, the whole perspex nose of the aircraft was covered with ice, and the pilot had to delay let-down and alighting for about 10 min while full output, cockpit heat dissipated the ice. There was no evidence of blade icing on this or any other occasion.

Initially, considerable glare was experienced in the cockpit, due to reflections from the navigation lights and flames from the exhaust. Coating the inside of the cockpit and the main rotor blades with black paint minimized this glare. Satisfactory results were then achieved for ordinary night flying. But, in cloudy and hazy weather, glare from the navigation lights gave the pilot a most uncomfortable feeling—likened to flying into a solid object.

Of primary interest are the views of several pilots who flew the bulk of the night mail operation. They felt that future flying equipment must be: (1) multi-engined, (2) stable, (3) simple and not tiring to fly in full I.F.R. conditions, and (4) free from cockpit glare at night. Ground equipment must also be improved, particularly navigational aids.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

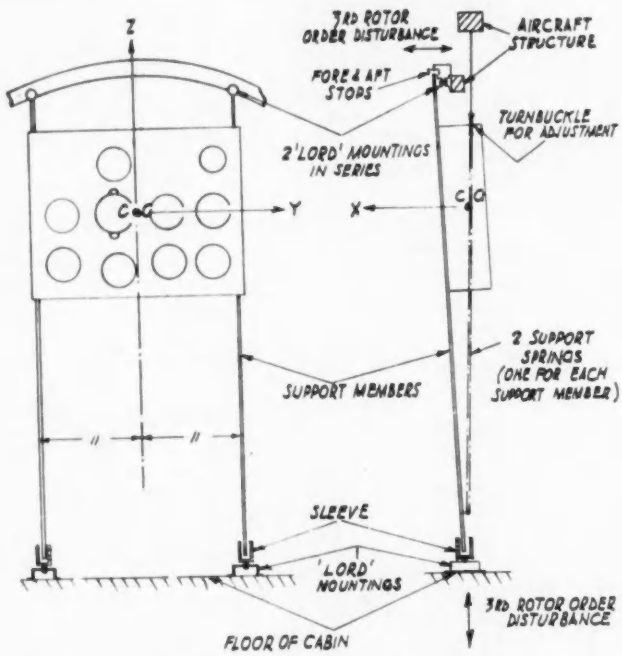


Fig. 4—Rear cockpit instrument panel was flexibly mounted to prevent undue vibration of instruments

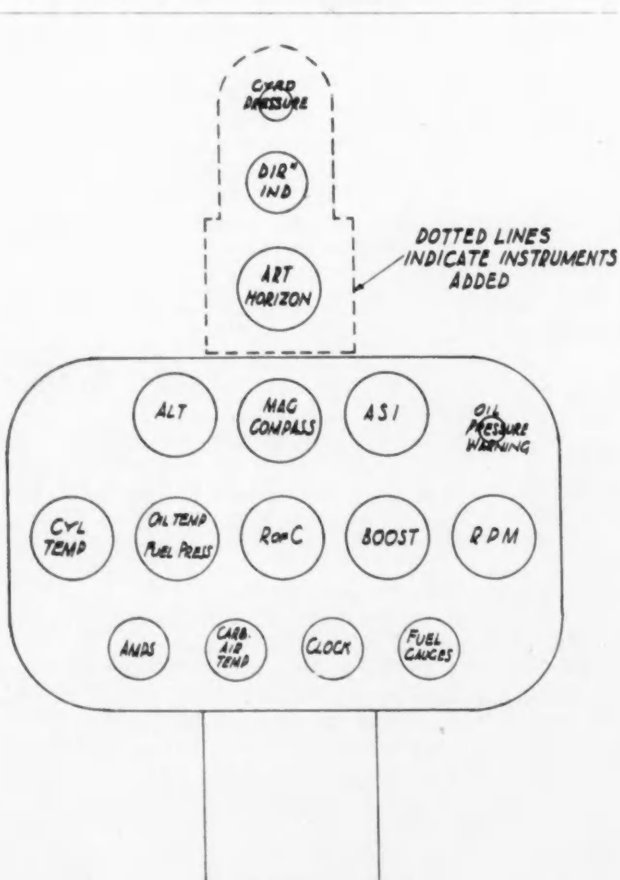


Fig. 5—Instrument arrangement in front cockpit for experimental night flying trials

First in SAE Journal Series Of Research Group's Reports To ISTC Division XXIX on

Tests for SAE Grade 5 Bolts

THE SAE Recommended Practice "Physical Requirements for Bolts, Capscrews, Studs, and Nuts" appears to do a generally satisfactory job of specifying the tensile properties of SAE Grade 5 bolts in the $\frac{1}{2} \times 2\frac{1}{2}$ in. size and NF or NC threads.

This is concluded from a study made by the Research Subdivision of Division XXIX—Nuts, Bolts, and Fasteners of the SAE Iron and Steel Technical Committee.

The investigators feel that their data could well be assumed to apply also to bolts 2½ in. long with diameters under ½ in. Work on diameters over ½ in. and on lengths over 2½ in. remains to be done.

Procedure

The procedure employed in obtaining the data was to acquire approximately 10,000 bolts of each thread series, made from the same heat of steel, and hardened as one lot. These hardened bolts were then tempered to certain hardness levels. The heat analysis was 0.42% C, 0.82% Mn, and 2.25% Si. By actual checks on the bolts, the average carbon content was 0.45%. The grain size of the heat was ASTM 3-4.

Random coded samples were sent, with adequate testing instructions, to at least seven laboratories. The laboratories participating in the testing program were those of the Caterpillar Tractor Co.; Deere & Co.; General Motors Corp.'s Electro-Motive Division, Truck and Coach Division, and Detroit Diesel Division; International Harvester Co.'s Manufacturing Research; National Screw and Manufacturing Co.; Russell, Burdsall & Ward Bolt and Nut Co.; and the Lamson Sessions Co. Ten samples were used for the determination of each property at each hardness level.

In this article, the data is related to Rockwell C

Aim is to improve the SAE Recommended Practice

IN 1948, the SAE Iron and Steel Technical Committee's Division XXIX prepared for publication in SAE Handbook the SAE Recommended Practice "Physical Requirements for Bolts, Capscrews, Studs, and Nuts." Since then, work has been carried on by the Research Subdivision of Division XXIX with the aim of gathering information on the physical properties of bolts which could bring about improvement of the SAE Recommended Practice. It is recognized that this information will also lead to a wider acceptance of the SAE Recommended Practice.

This report is the first in a series of articles presenting information developed by the Research Subdivision.

The accompanying article deals with the properties of SAE Grade 5 bolts in static tension. The purpose of these tension tests was to record the properties using the new testing methods incorporated in the SAE Recommended Practice and to compare and contrast them with older methods. These tests were limited to $\frac{1}{2} \times 2\frac{1}{2}$ in. hexagon head bolts in the fine and coarse thread series. This Grade 5 is a quenched and tempered bolt or stud made from medium carbon steel.

In reviewing the data, the Subdivision noted that carbon steel can produce bolts which meet the requirement recommended for alloy steel bolts.

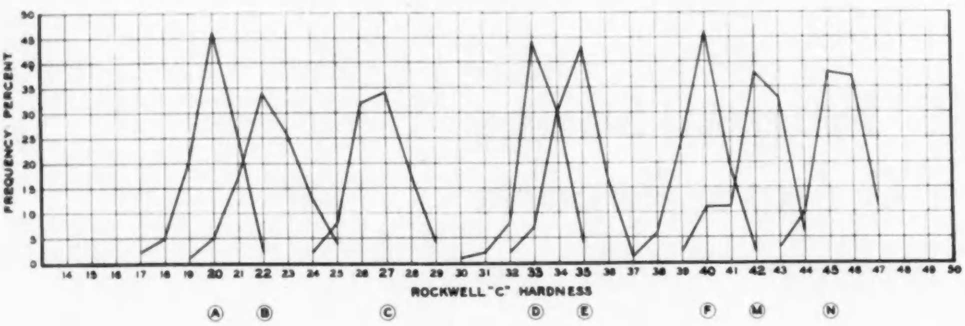


Fig. 1—Frequency curve of fine thread series bolts tempered to various hardness levels

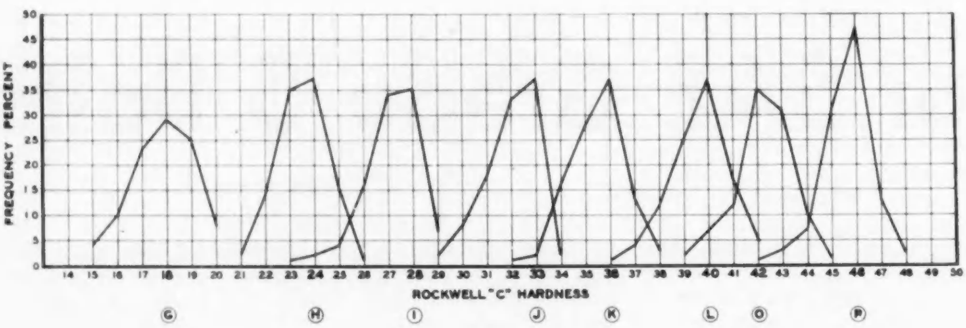


Fig. 2—Frequency curve of coarse thread series bolts tempered to various hardness levels

hardness taken in accordance with this SAE Recommended Practice on Physical Requirements for Bolts, Capscrews, Studs, and Nuts which reads in part: "The hardness shall be measured on transverse section through the threaded portion of the bolt at a point one quarter of the nominal diameter from the axis of the bolt. This section shall be taken one diameter from the end of the bolt. Either the Brinell or Rockwell method of hardness testing may be used."

It was thought for clarity of presentation that it would be advisable to relate the determined properties to hardness, inasmuch as hardness is a basic property and is substantially independent of both the shape and size; and as hardness is a commonly determined property it would be reasonable to expect a close correlation between the participating laboratories. Furthermore, this method of testing is within the reach of a greater number of producers and users; therefore, reporting on a hardness basis appeals to a larger audience.

The hardness for each level was reduced, by a simple statistical method employing frequency charts, to a whole number for each hardness level. These charts were constructed using individual hardness readings of from 200 to 500 for each code.

The frequency charts are shown as Figs. 1 and 2. The mode—or the reading occurring the greatest number of times—is used as the hardness of the coded group. It will be noted that curves have a greater spread on the lower side. The total spread is from 5 to 7 points. This is presumed to be due to the method of surface preparation as well as the natural variation in testing machines.

Correlation of Hardness at Two Spots

As hardness readings taken according to the method described in the SAE Recommended Practice destroy the bolt, it seems essential to correlate this hardness with hardness at some other location which will not destroy or impair the value of the bolt.

In these particular tests there was an exact correlation between the Rc hardness taken by the prescribed method and Rc hardness taken on the end of the threaded section after removal of surface irregularities. This correlation would not necessarily hold true on bolts over ½ in. in diameter due to the relatively low hardenability of C1040 steel.

Correlation of Rc & Brinell Hardness

Brinell hardness readings were taken on the top of the head of the bolt after removal of the decarburized surface using a 10 mm standard ball and a 3000 kilogram load at certain hardness levels. The correlation obtained is shown in Fig. 3.

The solid line is the conversion line taken from the SAE General Information Report on Hardness Tests and Hardness Number Conversions in SAE Handbook. The dotted line is a mean line taken from the test data. This mean line is a combination of the bolts of both the fine and coarse thread series. There is a close correlation between the SAE conversion data and the data obtained from the tests. An analysis of the data submitted by the participating laboratories shows a test error is to be expected of $\pm$ 0.05 mm in impression diameter.

This correlation between Rc hardness and Brinell hardness would not necessarily be true for larger diameter bolts due to the relatively low hardenability of C1040 steel.

Tension Testing

The SAE Recommended Practice specifies in addition to hardness two methods of checking for conformance to requirements:

1. Tensile Strength (Wedge Loading)— The SAE Recommended Practice reads in part: "The bolt shall be subjected to the proof load. . . . Then a 10

eg wedge shall be placed under the head of the olt and the tensile test continued until failure. To neet the requirement of this test there must be a ensile failure in the body or threads with no fracture of the head. The bolt shall meet the requirement for minimum tensile strength . . . without ailure." The minimum tensile strength requirement for Grade 5 bolts up to and including ½ in. diameter is 125,000 psi.

2. *Elastic Proof Load*—The SAE Recommended Practice describes the method for the determination of elastic proof load as follows: "In determining conformity to specifications for proof load, the overall length of a straight sample bolt or stud shall be measured at the true centerline. The preferred method of measuring the length shall be between conical centers on the centerline of the part using mating centers on the measuring anvils. Other recognized methods may be used such as ball-point anvils on prepared surfaces at the true centerline. The sample part shall be marked so that it can be placed in the measuring fixture in the same position for all measurements. The measuring instrument shall be capable of measurement to 0.0001 in. The part shall then be loaded as in the tensile-strength test to load equal to the specified elastic-proof load, then removed from the testing machine and its overall length again determined. The length after loading shall not exceed that before loading by more than 0.0005 in."

A fixture for measuring the length of a bolt before and after applying the proof load is shown in Fig. 4. To obtain accurate measurement it is advisable to face off both the ends of the bolt so that they are parallel within 0.0001 in.

The proof load requirement for Grade 5 bolts is set up as a minimum of 90,000 psi for sizes up to and including ½ in.

The tensile strength (wedge loading) and the load required to produce a permanent set of 0.0005 in. is shown in Table 1.

These data are shown in graphical form in Fig. 5.

Prior to the introduction of the insertion of a 10

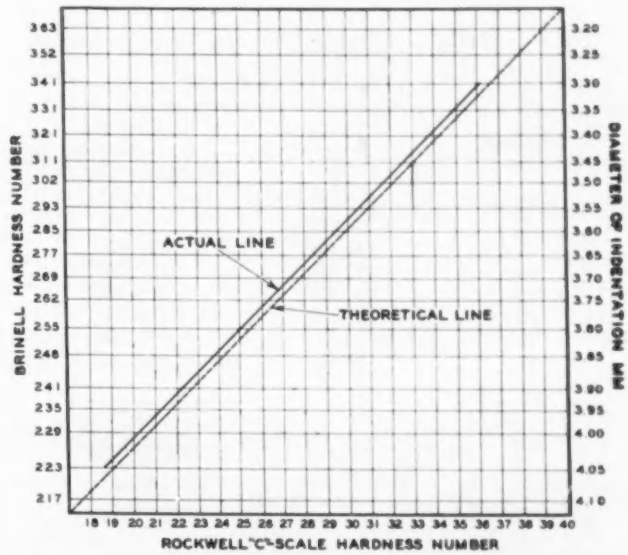


Fig. 3—Correlation of Rc hardness at an area ½ in. from the end of the bolt and Brinell hardness on top of head at various hardness levels

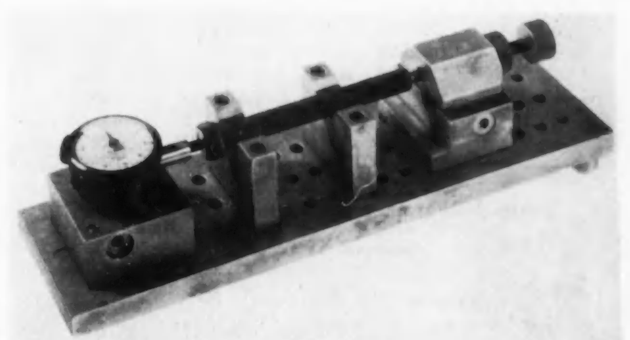


Fig. 4—Fixture for measuring length of bolt during proof load determination

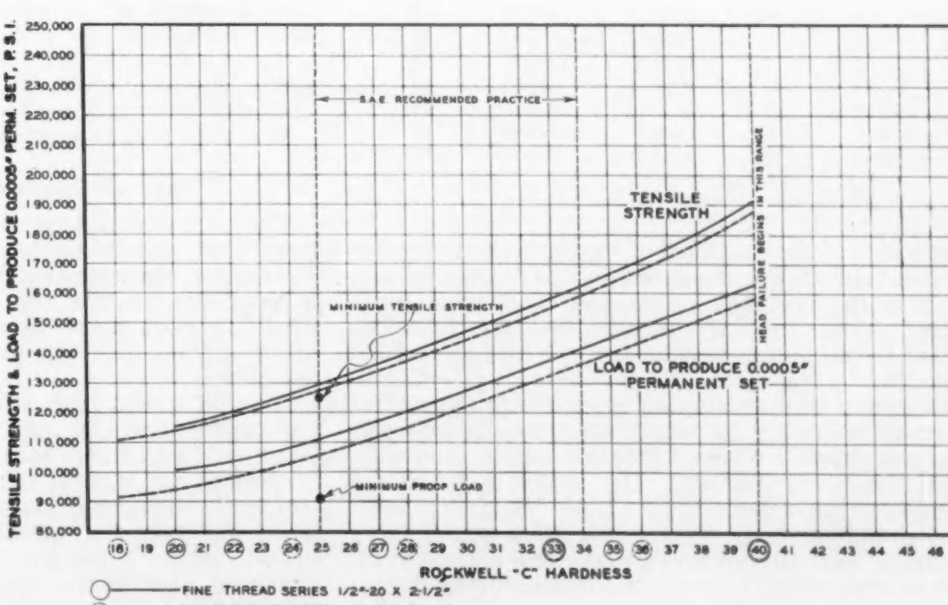


Fig. 5—Tensile strength (wedge loading) and load required to produce 0.0005 in. permanent set

Table 1—Tensile Strength (Wedge Loading) and Load to Produce 0.0005 in. Permanent Set

Fine Thread Series			Coarse Thread Series		
Hardness, Rc	Tensile Strength, psi	Load to Produce 0.0005 in. Permanent Set, lb	Hardness, Rc	Tensile Strength, psi	Load to Produce 0.0005 in. Permanent Set, lb
20	114,600	99,900	18	110,900	91,500
22	119,600	103,900	24	125,000	102,800
27	135,900	117,400	28	135,600	114,400
33	160,000	140,900	33	154,000	130,300
35	166,600	148,400	36	168,800	144,400
40	187,500	160,900	40	187,900	158,200
42	Failure	172,200	46	Failure	180,800
45	Head	184,700	42	Head	169,500

Table 2—Yield Strength, Tensile Strength, and Elongation (Axial Loading) of 1/2 in. SAE Grade 5 Bolts

Fine Thread Series				Coarse Thread Series			
Hardness, Rc	Yield Strength, psi	Tensile Strength, psi	Elongation, in.	Hardness, Rc	Yield Strength, psi	Tensile Strength, psi	Elongation, in.
20	98,600	114,900	0.157	18	91,800	111,200	0.110
22	102,700	119,900	0.137	24	103,100	124,300	0.086
27	116,200	135,900	0.095	28	115,100	135,600	0.064
33	139,000	160,600	0.056	33	130,300	154,000	0.045
35	146,200	167,200	0.050	36	144,800	170,600	0.035
40	175,100	194,100	0.040	40	166,300	191,400	0.032
42	182,800	207,600	0.032	42	171,500	204,800	0.026
45	200,500	232,000	0.019	46	189,000	226,000	0.016

Table 3—Permanent Set at Yield Strength

Bolt Size, in.	Permanent Set at 0.2% Offset (in.)			
	Threads	NC	NF	Threads
1/4	20	0.00030	0.00021	28
5/16	18	0.00033	0.00025	24
3/8	16	0.00038	0.00025	24
7/16	14	0.00043	0.00030	20
1/2	13	0.00046	0.00030	20
9/16	12	0.00050	0.00033	18
5/8	11	0.00055	0.00033	18
3/4	10	0.00060	0.00038	16
7/8	9	0.00067	0.00043	14
1	8	0.00075	0.00050	12
1-1/8	7	0.00086	0.00050	12
1-1/4	7	0.00086	0.00050	12
1-3/8	6	0.0010	0.00050	12
1-1/2	6	0.0010	0.00050	12

deg wedge under the head of the bolt during tension testing and the use of a proof load to determine conformity to specification, tension tests were made under axial loading conditions. Specifications called for minimum tensile strength and often yield strength.

Plasticity was determined by elongation measurement by using a gage length of three threads plus the body length. Where the body diameter is greater than the pitch diameter, the major part of the elongation took place in the threaded area. With pitch-diameter-body bolts, elongation would likely occur in both thread and body. These elongation values were found to be of doubtful accuracy due to the difficulty of joining the broken ends of the bolts.

The determination of the yield strength was found to be difficult, especially in higher hardness ranges. Below 24 Rc where there is a yield point, the correlation between laboratories was good. Above this hardness, the correlation became increasingly poorer as the hardness increased.

During the course of these tests an extensometer was developed (Fig. 6) which drew an accurate load-extension curve to the point of failure of the bolt. From this curve, using 0.2% offset, the determination of the yield strength became accurate and the measurement of the elongation of the bolt also became reliable.

Table 2 gives the tensile strength from all laboratories, the yield strength and elongation from laboratories having improved equipment.

This data is shown graphically in Fig. 7.

Ratio of Tensile to Yield Strength

The ratio of tensile strength to yield strength has been used as a basis for specification where it is stated that the ratio shall not be less than 115%. It is axiomatic to state that before this ratio can be used, the yield strength must be accurately determined. What this ratio means in scientific terms is not clear.

It would appear from Fig. 7 that the ratio between the tensile strength and yield strength is a constant over a hardness range of from 18 to 40 Rc. A microstructure is being considered which consists of tempered martensite. It has been established from other test data that should a microstructure consist of higher decomposition products as well as tempered martensite that the ratio between the yield and tensile strength would be greater. This

structure would be produced by "slack" quenching; in other words, part of the quenched steel would be cooled at a rate less than the critical cooling rate. If it were greater, then the ratio specification would show preference for a "slack" quenched bolt over a bolt with a microstructure of tempered martensite. This would not seem to be a desirable conclusion.

It may be true that the gap between the yield and tensile strength would be less if (1) the carbon content of the steel were 0.60% or greater, (2) the hardness was 45 Rc or greater, and (3) the bolts contained external or internal cracks due to excessive cold work or quenching conditions.

It would appear that the use of a 10 deg wedge under the head in testing would insure that the bolt would not be so brittle that it would not show a gap between the yield strength and the tensile strength, which is presumed to be the reason for specifying a tensile-yield ratio.

Wedge Loading

It was part of this investigation to study the efficacy of wedge loading. The object of inserting the 10 deg wedge under the head of the bolt is to eliminate bolts with defective heads and also to measure indirectly the ability of the bolt to withstand non-axial loading. With bolt heads produced under sound practice as represented by these test bolts, failure at the head takes place at about 40 Rc. See Fig. 5. The correlation between laboratories was very good up to 40 Rc. Over this point the location of bolt breakage varied from laboratory to laboratory, indicating that some aspects of testing were not truly standardized. There need not be too much concern on this account as the maximum specified hardness of any of the SAE grades of bolts does not exceed 38 Rc.

Elastic Proof Loading

Bolts exhibiting 0.0005 in. permanent set would have exceeded the yield strength where the yield strength is determined by 0.2% offset up to and including the following sizes:

½ in. diameter—13 threads per in.
⅞ in. diameter— 9 threads per in.

Table 3 gives the calculated permanent set at 0.2% offset for sizes up to and including 1½ in. in both the fine and coarse thread series.

The load required to produce a permanent set of 0.0005 in. appears to be somewhat difficult to obtain. The tensile machines must be very accurate, and there is a factor of time under load involved. However, where the proof load is set lower than the yield strength, as is the case in this SAE Recommended Practice, an exact determination would seldom be necessary when the minimum hardness requirement is 25 Rc. From tests made on these ½ in. diameter bolts, it would appear that at 20 Rc a permanent set of 0.0005 in. would not be expected. See Fig. 5.

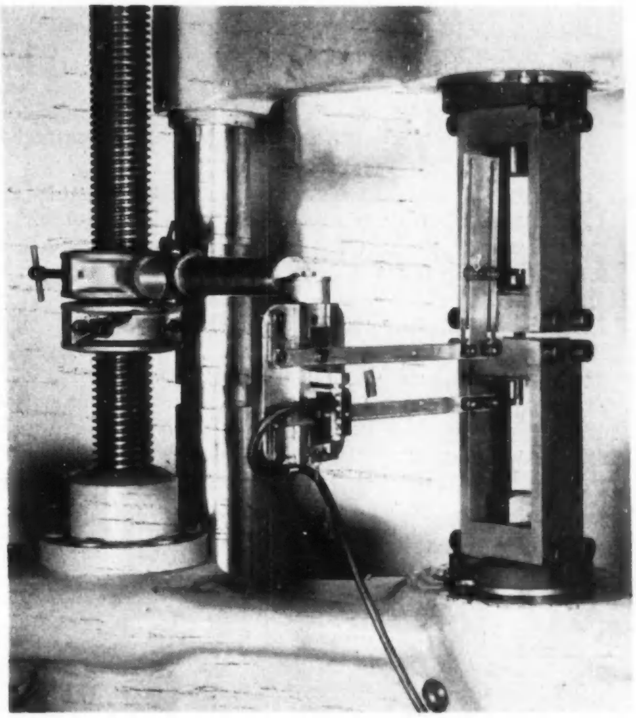


Fig. 6—Extensometer for measuring change in length during tensile testing (axial loading)

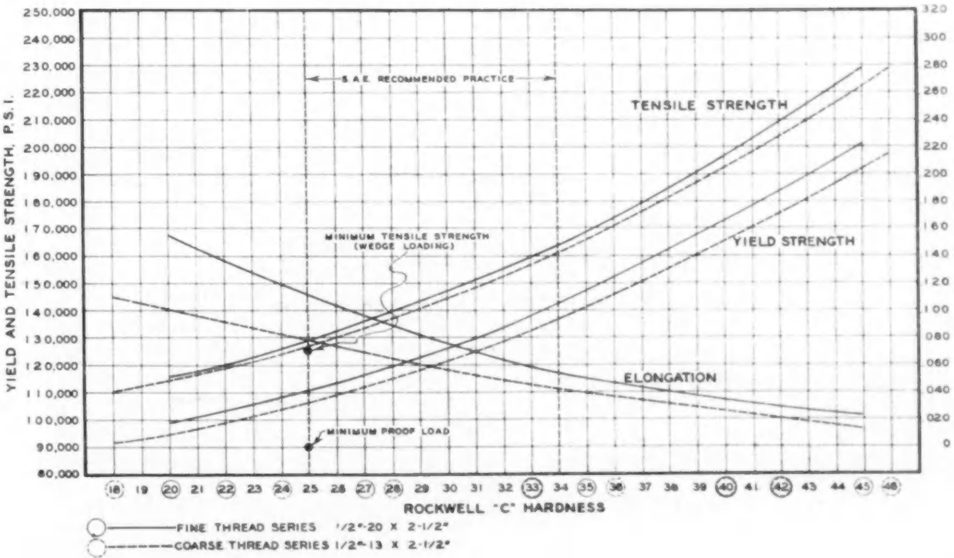


Fig. 7—Tensile strength (axial loading), yield strength, and elongation

Petroleum Requirements

Next month's SAE Journal will carry Part II—Lubricants, of this two-part article.

IT is essential that an aircraft gas turbine fuel

1. maintain stable combustion without forming deposits under all engine operating conditions.
2. not be lost from the aircraft tanks under any flight conditions.
3. be easily transferable from the aircraft tanks to the engine.
4. be available in adequate quantity.

These requirements may be considered most conveniently in relation to the five types of fuel on which there is operating experience. Table 1 shows the more important typical characteristics of these.

Engine Requirements

The general design of combustion systems of contemporary British engines, whether multi-unit or single annular chamber, has followed two distinct and different paths:

1. The liquid-spray injection system as developed by Joseph Lucas Ltd.

2. The prevaporizing system developed by Armstrong Siddeley Motors Ltd.

Representative units are shown in Figs. 1 and 2. The two systems differ in many respects particularly in terms of the time interval between vaporization and the start of combustion. In the Lucas systems, the fuel enters the combustion chamber in a liquid spray; vaporization of individual droplets takes place as a result of "skinning," and this is followed by burning. In the Armstrong Siddeley system, the less finely divided spray is vaporized and partly mixed with air before it enters the combustion space proper. Both are faced with the same problems of (1) maintaining steady combustion over the range of fuel flow of approximately 40:1 associated with an inlet air temperature range of 280 C(536 F) to -40 C (-40 F) as set by the operating range of the engine from full power at sea level to idling at great heights and (2) of diluting the combustion gases without chilling the flame with resulting poor combustion efficiency, to an exit temperature of approximately 1170 K (2105 F absolute), which is the present limit set in order to maintain adequate turbine blade life.

Both systems, too, are susceptible to derangement by the formation of deposits on the fuel-injection nozzles or vaporizers if unsuitable fuels are used, which may interfere with the combustion pattern and temperature distribution across the systems resulting in liner buckling and failure.

Combustion Stability

These combustion systems and their associated fuel-injection equipment have been developed to a point where almost any fuel which can be transferred from the aircraft tanks to the engine can be burned with high efficiency at any altitude. Certainly all of the fuels considered in Table 1 can be burned efficiently provided that the combustion system is designed for the particular fuel on which it must operate. Earlier expectations that the combustion system would prove to be completely omniv-

Table 1—Typical Characteristics of Five Gas Turbine Fuels

Fuel	Specific Gravity, 60/60	Flash Point, C (F)	Freeze Point, C (F)	End Point, C (F)	Reid Vapor Pressure, psi
Kerosene	0.805	40.6 (105)	-45 (-49)	290 (554)	Negligible
Wide Range	0.77	-34.4 (-30)	-65 (-85)	310 (590)	5-7
Medium Range	0.78	-11 (12)	-65 (-85)	310 (590)	1-2
High-Flash Kerosene	0.835	68.3 (155)	-45 (-49)	260 (500)	Negligible
Aviation Gasoline	0.715	-34.4 (-30)	-65 (-85)	160 (320)	5-7

# of British Gas Turbines

EXCERPTS FROM PAPER BY

Kenneth C. Hunt, Manager, Technical Division, Esso Petroleum Co., Ltd

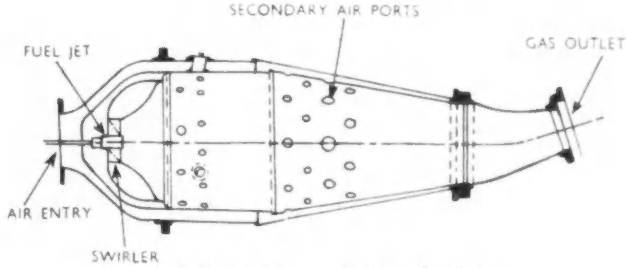
• Paper "The Development of the Aircraft Gas Turbine in Great Britain and Its Influence on Petroleum Requirements" was presented at SAE Metropolitan Section, January 4, 1951.

erous have not quite been realized, particularly as far as the maintenance of stable burning when idling at altitude is concerned.

Fuel systems on British engines fitted with Lucas-type combustion equipment today operate at pressures of between 1500 and 2000 psi at maximum power. With a fixed-orifice burner, the pressure needed to give the fuel flow required for idling at altitude is not more than 1 psi at which pressure effective break up of the fuel cannot be obtained. Because of the square-law flow characteristics of a simple orifice, a doubling of altitude idling pressure can be obtained only by a corresponding two-fold increase in the maximum power pressure. This is prohibitive in that a pump to work satisfactorily at such pressure has yet to be developed. The prevaporizing combustion system is able to work over a rather lower pressure range.

Some improvement in air/fuel mixing at these low fuel flows can be provided by an increase in fuel volatility, which in the Lucas system raises the maximum size of droplet which can be burned in the time available by increasing its decay rate and decreases the limiting vaporizer temperature in the Armstrong Siddeley system. However, the volatility of a fuel is limited by the aircraft fuel system. The engine designer cannot look to more volatile fuels to improve combustion at low fuel flows. He must seek other solutions. Continously variable or two-stage variable orifice injection nozzles (such as Duplex) are of considerable assistance because they maintain good atomization at low fuel pressures. Alternatively, the "spill" type of burner may provide a solution to the problem, though matching an engine set is a matter of some difficulty.

The problem of relighting a "dead" engine at altitude is akin to, but more difficult than that of maintaining steady combustion at idling speeds. It may be that improved torch igniters or high-frequency spark gap techniques or both will provide the answer. But under critical conditions it is more



1—Lucas-type combustion chamber

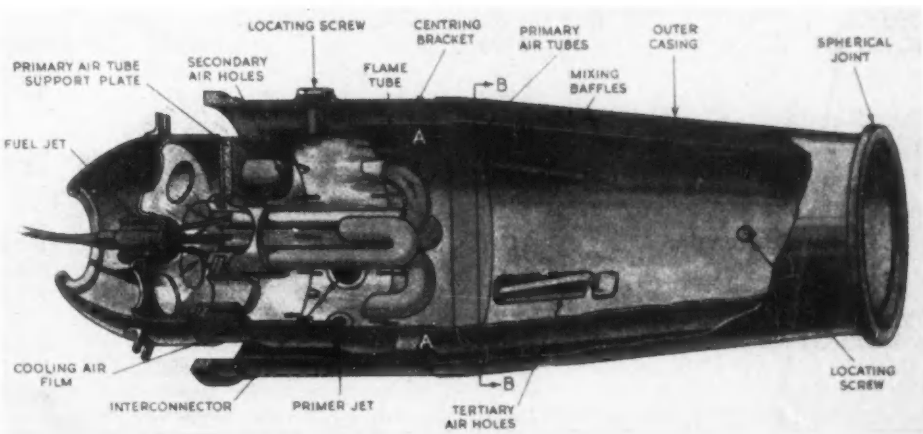


Fig. 2—Armstrong Siddeley-type vaporizer combustion chamber

probable that some form of gas starting will be necessary.

The effect of viscosity on fuel spray characteristics is well known. Experience suggests that a viscosity of 10 cs should not be exceeded at the injection nozzle if good atomization is to be obtained. However, this is not a serious limitation on fuel quality because fuels which are otherwise suitable for use in the aircraft gas turbine will be found to have viscosities lower than this at the lowest temperature at which they will reach the injector.

Combustion System Deposits

Although by far the greatest amount of engine operating experience has been with kerosene-type fuels having an aromatic content of about 7% and sulfur content of about 0.05%, sufficient running has been done with fuels of higher aromatic and sulfur contents to suggest that these components of a fuel vitally affect engine serviceability. The effect of high gum content has not yet been examined.

Carbon deposits in spray injection-type combustion systems are usually the result of air stagnation around the fuel injector nozzle face which permits the "fraze" from the spray to settle on the injector face, where it is cracked and carbon build up follows. This carbon then interferes with the liquid spray pattern. Poor temperature distribution across the combustion space follows and that part of the spray which has been misdirected on to the liner walls cracks, with the formation of a carbon layer. The thermal insulating properties of this layer cause liner buckling and further deterioration in combustion conditions which may eventually result in complete failure. Such a condition may be avoided by insuring that there is adequate air scouring of the injector nozzle face.

The effect of an increase in the aromatic content of the fuel is felt as a decrease in the time required to build up such deposits, but it is secondary in importance to the purely physical phenomena.

In the prevaporizing systems, highly aromatic fuels may give rise to carbon deposits in the vaporizer tubes as the result of cracking, but these have not been found to be of serious magnitude.

The effect of sulfur is less easy to define. There is evidence that high-sulfur-content fuels foster carbon deposition probably as the combined result of strengthening the carbon structure and also making the combustion chamber walls more retentive. The deleterious effects of sulfur will more likely be seen in corrosion, starting with intercrystalline penetration of the hotter parts of the system. Such effects, however, usually become apparent only after considerable engine running. Only time and many thousands of flight hours will establish safe aromatic and sulfur limits. Experience in Great Britain suggests that fuels having aromatic contents of 20% and sulfur of 0.2% may be burned without seriously reducing engine serviceability. However, much of the experience from which these limits can be deduced has been on comparatively narrow boiling range fuels of the kerosene type. It is more than possible that if and when wider boiling range

Table 2—Aromatic, Sulfur, and Gum Contents of Fractions of a Wide-Range Fuel

Boiling Range of 20% Fraction, C (F)		Aromatic Content of Fraction, % by weight	Sulphur Content of Fraction, % by weight	Preformed Gum Content of Fraction, mg/100 g
17-123	(62.6-253.5)	2.0	0.02	1.0
123-143	(253.5-289.5)	5.5	0.21	1.0
143-198	(289.5-388.5)	28.5	0.25	9.0
198-232	(388.5-450)	44.0	0.66	6.0
232-304.5	(450 -580)	55.0	1.05	197.0

Table 3—Effect of Fuel Characteristics on Range

Fuel	Probable Widest Specific Gravity Range	Specific Gravity of Typical Sample	Net Heat of Combustion, Btu/lb	Net Heat of Combustion, Btu/imp. gal	Relative Range of Aircraft (kerosene of Specific Gravity of 0.805 = 1)	Relative Weight of Fuel per Unit Volume (kerosene of Specific Gravity of 0.805 = 1)
Type A						
Kerosene	0.790		18,670	147,490	0.985	0.981
	to	0.805	18,600	149,730	1.000	1.000
	0.830		18,480	153,380	1.024	1.031
Type B and C						
Wide Range	0.750		18,850	141,380	0.944	0.932
	to	0.770	18,780	144,610	0.966	0.956
	0.790		18,670	147,490	0.985	0.981
Type D						
High-Flash Kerosene	0.800		18,620	148,960	0.995	0.994
	to	0.835	18,460	154,140	1.029	1.037
	0.860		18,330	157,640	1.053	1.068
Type E						
Aviation Gasoline	0.690		19,100	131,790	0.880	0.857
	to	0.715	18,990	135,780	0.907	0.888
	0.735		18,920	139,060	0.929	0.913

fuels come into the picture, the aromatic and sulfur distribution and the form in which the sulfur compounds are present will have to be controlled as well as the total maximum amounts of these compounds.

A typical wide-range fuel gave the results shown in Table 2.

The concentration of the bulk of the aromatics, sulfur and gum-containing compounds in the least volatile, most viscous fraction may well result in a level of engine deposits and corrosion quite out of proportion to that which would be predicted from a simple inspection of the fuel.

Much work remains to be done on the type of sulfur compounds which can be permitted. In this connection recent work in the United States suggesting a severe limitation on mercaptan sulfur is of note.

Specific Gravity and Engine Control

Contemporary fuel pumps rely on the centrifugal pressure produced in part of the pump assembly to control maximum fuel delivery and so provide automatic engine overspeed governing. The centrifugal pressure is a function of fuel density and engine speed. Thus, although the overspeed governing characteristics of a pump can be set accurately for a fuel of any desired specific gravity, it is important that the selected gravity should be maintained. An unannounced change to a fuel of lower specific gravity than that for which the pump has been set will result in overspeeding of the engine and possible failure, while an increase in gravity will reduce maximum engine speed and so reduce maximum power.

Fuel specifications which permit wide variation in specific gravity may therefore introduce operating difficulties in the field.

Specific Gravity and Range

Gas turbine engined aircraft are high-speed types with high wing loadings and so have short thin wings. Thus they are restricted in volumetric fuel capacity. Besides, specific fuel consumption of the gas turbine is high—particularly when the powerplant is operated at other-than-optimum altitude and speed. These two characteristics make a fuel of high heat content per gallon particularly desirable. Table 3 indicates the importance of this and has been drawn up on the assumption that "Relative Range of Aircraft" is directly proportional to the heat of combustion per gallon of fuel.

A high specific gravity fuel is at a premium, the difference in aircraft range between the lightest and the heaviest fuels considered being 17%.

Volatility

Turbine-engined aircraft in the near future will operate at 60,000 ft and have a maximum rate of climb about 25,000 fpm. It follows that the fuel will have no significant time in which to cool down. Unless fuel tanks are pressurized, the tankage and fuel system must be capable of storing and handling fuel at ground-level temperature at pressures of 60 mm Hg. Boiling will occur, with consequent loss of fuel from the tank vents, a condition which may be aggravated by the sudden release of dissolved air and vapor, carrying liquid fuel with it.

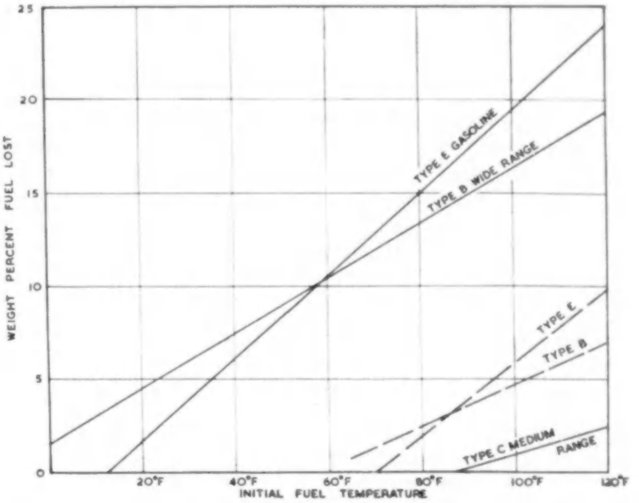


Fig. 3—Fuel loss by boiling at 60,000 ft. Dashed lines for Types B and E represent fuel pressurized 2 psi

A gas-turbine-engined aircraft can ill afford such losses.

Losses due to simple boiling for typical fuels of the five types under consideration are shown diagrammatically in Fig. 3. In the worst case, the loss may reach 25%. The behavior of gasoline-type fuels is dependent also on the shape of the distillation curve. The low loss with the Type C fuel should be noted. No loss whatsoever was observed with Types A and D. The data from which these curves were prepared were obtained experimentally in the laboratory. The figures are for equilibrium conditions, and the loss is therefore independent of the rate of climb. The loss with the wide-range fuel of 5–7 psi Rvp is a little less than that of aviation gasoline of similar vapor pressure due to the buffer effect of the heavy ends in the former fuel.

Rate of climb has a secondary effect in that given the right conditions of agitation and ratios of fuel volume to tank volume, a "supersaturated" condition can be built up which leads to heavy foaming and boiling with bumping followed by excessive carry over of liquid fuel with the vapor and recently dissolved air. Total losses as high as 70% have been recorded in the laboratory under these conditions, but it is not known how the laboratory tests would relate to actual flight. Even under laboratory conditions it was found that the condition of the inner tank surfaces was significant.

The release of dissolved air under orderly conditions without supersaturation appears to be insignificant in its effect.

The foregoing data suggest that reliance cannot be placed on the high volatility of a 5–7 psi Rvp fuel to compensate for inherent deficiencies in the engine combustion system, because after some time at altitude, when stable fuel tank conditions have been reached, what was originally a 5–7 psi Rvp fuel will have deteriorated to a 1–2 psi Rvp fuel. Such topping operations are much better done at the refinery.

The vapor loss curves show how effective fuel cooling would be if it could be done economically. It is, however, quite impracticable to cool adequately

Table 4

Fuel	Initial Fuel Temperature, C (F)	Fuel Lost During Climbs to 60,000 Ft Pressurized to 2 psi gage, %	Pressurization Required to Prevent Loss at 60,000 Ft, psi gage
Type B			
Wide Range	15.6 (60)	0	1.8
	37.8 (100)	5.8	4.7
Type C			
Medium Range	15.6 (60)	0	0
	37.8 (100)	0	0.2
Type E			
Gasoline	15.6 (60)	0	1.1
	37.8 (100)	4.8	3.6

in flight without severe weight and drag penalties. Ground precooling is not feasible on a world-wide basis, though it does have the merit of keeping the complications on the ground instead of adding them to the aircraft. There are also obvious operational difficulties to be considered with the use of precooled fuel—a delayed take-off being one.

Fuel loss with the more volatile fuels can be reduced by pressuring the tank at the expense of a weight penalty. The scope of this palliative is shown in Table 4. It will be seen that pressurization to 5 psi is necessary before fuel loss with a 5-7 psi Rvp fuel can be reduced to an acceptable figure. This degree of pressurization would appear to be impracticable on account of the excessive weight penalty and complication involved.

Partial pressurization to 2 psi would reduce the weight penalty to about 25% of that 5 psi pressure, but the vapor loss with a 5-7 psi Rvp fuel with this degree of pressurization is still prohibitively large.

The engine pump must be supplied continuously with solid fuel free from vapor bubbles. All modern aircraft are fitted with submerged booster pumps, and vapor locking in the fuel system need not be anticipated with any combination of fuel and tank system which is free from the excessive vent loss just discussed.

The foregoing may be summarized by saying that fuels of Reid vapor pressure higher than 1-2 psi are quite unacceptable and can, in fact, be used only at the expense of considerable weight and performance penalties.

Freezing Point and Pumpability

The engine must be fed with clean fuel, and felt filters are commonly used in the fuel system. These are susceptible to blocking with the ice crystals which form as the result of freezing out of dissolved water, and also to blocking with solid hydrocarbons which are precipitated below the freezing point of the fuel.

Work is underway to determine to what degree fuels can be pumped below their nominal freezing points. The severity of filter blocking would seem to depend very much on the temperature of the filter, the flow rate through it, and the rate of resolution of the solid material. Considerable hysteresis effects are anticipated.

Felt filters of the size normally associated with a 5000-lb thrust turbojet engine have been found to pass about 1000 gal of fully water-saturated fuel at -40 C(-40 F) before the pressure drop due to plugging with ice crystals becomes excessive. Operational difficulties may therefore not prove to be severe.

Tank heating is impracticable except as a last resort. It involves the aircraft in a bigger weight penalty than does tank pressurization. It is not safe to rely on adiabatic and on air-friction heating of the tanks, which are a function of aircraft speed.

Nothing but experience of a wide range of aircraft operations will enable a realistic freezing point to be decided on. For years aviation gasoline with a maximum freezing point of -60 C (-76 F) has been used satisfactorily throughout the world. There is little evidence that a lower figure than this need be called for in a turbine fuel. All types of operation should be satisfied with it.

There is also strong possibility that purely civil requirements could be satisfied with a fuel of high freezing point of around -45 C (-50 F).

Safety

Operators of commercial aircraft *must* provide the highest practicable degree of safety, and there is no reason to add unnecessarily to the normal risks of military flying. It is now generally accepted that the higher the flash point of the fuel, the less the risk of accidental ignition in an accident of the heavy-landing type. Also the higher the flash point, the slower is the spread of the fire should one start. For this reason it is accepted in Great Britain that the development of the gas turbine for civil aviation must be associated with the use of fuels of kerosene type having flash points over 37.8 C (100 F). It is highly desirable that these fuels should be used in military operations as well. Heavy landings of battle-damaged aircraft are a frequent occurrence.

Quality Versus Availability

It is clear that an acceptable fuel must have the following characteristics:

1. High specific gravity (or volumetric calorific value).
2. A vapor pressure of not more than 1-2 psi Rvp.
3. A freezing point of below -60 C (-76 F).
4. A flash point of over 37.8 C (100 F).
5. An end point of below about 310 C (590 F), not from theoretical considerations but because there is at present no experience with higher end-point fuels.
6. A maximum sulfur content of 0.2%, with the expectation that this may be increased to 0.5%.
7. A maximum aromatic content of 20%, with a probable increase as the result of experience to 25%.
8. Some limit on sulfur and aromatic distribution.

That is the target. Can it be reached?

It is beyond argument that at any given time aircraft must be capable of operation on such fuels as may be immediately available in adequate quantities, but there must not be complete preoccupation with immediate availability at the expense of loss of sight of what is really required. There is no doubt that civil requirements for gas turbine fuels can be met now and in the foreseeable future with the kerosene Type A fuel, particularly if an

easement in freezing point to -45 C (-50 F) is permitted. There is no technical reason why the freezing point should not eventually be brought down to the desired -60 C (-76 F).

It is the military situation which is so difficult to assess. However, it is most essential that quality and performance should not be sacrificed unnecessarily to quantity. The lesson of the last war was that in the air quality always beat quantity, and in the author's view it always will. However, the last war was fought with piston engines, and the influence of fuel quality, particularly knock rating, on possible engine power output and economy was clear beyond dispute. That is why the petroleum industry confounded some expert skeptics and produced 22,000,000 tons of 100 octane per year.

Unfortunately there is no single feature of a gas turbine fuel which is quite so clearly defined in importance as the knock rating of a piston engine fuel. But in the author's opinion the combined penalty of high vapor pressure and low specific gravity (hence low volumetric calorific value) of the wide-range 5-7 psi Rvp fuels prohibits their use in gas turbines as certainly as an 87-octane fuel would have proved useless in 1944. The combined penalty may reduce the aircraft range by as much as 25%. This is much more than the increase in aircraft range which followed the improvement in specific fuel consumption made possible by an increase in compression ratio of a piston engine uprated from 87 to 100 octane, and the greater take-off power which enabled bigger fuel loads to be carried.

For the immediate future an easement of the flash point limit provides the best compromise between usefulness in service and availability; though special consideration may have to be given to handling risks in ground storage. Considerable doubts were expressed some few years ago about the significance of the risks of handling 1-2 psi Rvp fuels, but it may be pointed out that considerable quantities of alkylate of this vapor pressure were moved long distances during the last war without trouble.

Even if special precautions prove necessary, some additional complications on the ground are a small price to pay for maximum performance in the air.

For the longer-term future, the author is firmly of the opinion that the full requirements must be met, and the petroleum industry must do the necessary work to determine how best to satisfy them. This problem is much easier than the one which the industry solved in 1940 in connection with the manufacture of Grade 100/130 gasoline, and the urgency is as great. There is no doubt that a fuel wholly acceptable to the engine and aircraft designer can be made in adequate quantities if the effort is put in. There is no room and no time for compromises which create dissatisfaction all round and seriously interfere with rational aircraft and engine development programs. Maximum aircraft performance must be obtained.

(Paper on which this abridgment is based is available in full in multilithographed form from the SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

DISCUSSION

By Hugh Harvey

Shell Oil Co., Inc.

IN the United States, where thus far the principal interest in jet aircraft has come from the military, there has been apparently more emphasis on availability than in Britain. This has led to the formulation of a specification for a wide-range jet fuel with a high vapor pressure.

To understand the factors affecting availability, we might consider a barrel of crude oil as a pie which can be divided into slices. The slice representing aviation gasoline can be varied in size as a result of synthetic processes that convert heavier fractions of crude oil into gasoline.

Unfortunately, kerosene cannot be economically synthesized from other fractions of crude oil, and our supply is limited by that which occurs naturally. This amounts to about 6% of the total crude production under present operating conditions, which means that in 1949 it would have been possible to make more than 12 million gal of kerosene a day from all the crude oil produced in the United States. Under the most favorable operating conditions, it might be possible to convert 10% of our crude production to kerosene. In 1949, this would have amounted to 20,000,000 gal a day. Even a small fraction of this amount would be ample to meet the needs of commercial jet aircraft in this country for many years to come.

The petroleum industry, however, is faced with the problem of gearing itself now to meet aviation fuel requirements in the event of a third world war. Teamwork and cooperation of the aircraft and petroleum industries and the United States government, through the National Advisory Committee for Aeronautics Subcommittee on Aircraft Fuels, are directed at this part of the industry-wide problem.

An appreciation of the magnitude of the fuel supply problem can best be had by considering that during World War II, 19,000,000,000 gal or 60 million tons of high-octane aviation gasoline were produced. The peak rate of aircraft fuel production was about 20,000,000 gal per day of high-octane gasoline or nearly 10% of the total rate of crude oil production. This quantity of high-octane gasoline would power 37,500 2000-hp reciprocating engines operating 4 hr per day with a fuel consumption of ½ lb of fuel per hp-hr. These engines could produce daily a total of 300,000,000 hp.

A glimpse of future requirements may be obtained when we realize (1) that jet engines generally use more fuel for each horsepower produced than do

the reciprocating engines, and (2) that jet engines are more powerful.

This increase in power is a direct reflection of the larger aircraft and higher speeds attained through aviation progress. A typical World War II fighter aircraft had one engine of about 2000 hp, while the largest engines were in the four-motor B-29 and were under 3000 hp each. Today, we have fighters such as the North American "Sabre" with a 5000-lb thrust turbojet, and bombers such as the B-45 with four 5000-lb thrust turbojets, and the B-47 with six 5000-lb thrust turbojets. A pound of thrust equals 1½ hp at 565 mph. If the 37,500 engines previously mentioned were 5000-lb thrust turbo jets operating 4 hr per day with a fuel consumption of 1 lb of fuel per lb thrust per hr, a hypothetical daily requirement for fuel would be 95,000,000 gal per day. This would be nearly half of the present rate of crude oil production in the United States.

Choice Is Wide-Range Fraction

Faced with a potential consumption such as this, the armed forces using jet aircraft looked for a fuel available in these quantities. The answer was to combine some of the slices of our pie, such as the gas oil, kerosene, and gasoline fractions. This led to the formulation of military specification MIL-F-5624, formerly known as AN-F-58, and more generally as JP-3. This is a wide-range petroleum fraction boiling from 105 to 600F. Looking again at the pie, it will be seen that this fuel can be made by combining half of the slices. In other words, JP-3 can utilize 50% of a barrel of crude oil as jet fuel. In doing so, all the available gasoline, kerosene, and diesel oil would be diverted. Obviously, this would leave virtually no supplies for other forms of transportation, and in the extreme case could leave all aircraft stranded on the flight line for lack of transportion for fuel and supplies. Fortunately, although the armed forces are buying limited quantities of jet fuel to this specification, the petroleum industry and the aircraft engine industry, and the Federal government are conducting studies aimed at determining what type of product will be suitable, in sufficient quantities, for turbojets. These studies are being carried on in the full realization that petroleum products are needed for automobiles, trucks, tanks, ships, diesel locomotives, and other required industrial civilian uses.

Safety

Fuels differ in their flash point, and in the rate at which they burn. On this basis, kerosene-type fuels have been regarded as safer than gasoline, for example. We must remember, however, that a fuel is made to burn, and that the relative degree of safety of kerosene over gasoline is marginal. There is the danger, if we emphasize the relative safety of low volatility fuels, that people will become careless in handling them, and results could be most unfortunate. The industry is becoming increasingly aware that this possibility is a potentially greater hazard than that inherent in the fuel itself.

If we will always go on the assumption that none of the fuels under consideration today is safe, we can more readily evaluate each. At sea-level conditions, aviation gasoline vapors are present in explosive concentrations between − 40 and + 20F, temperatures that occur while fueling takes place. Kerosene, on the other hand, is present in explosive concentrations between 95 and 170F, temperatures that are usually, though certainly not always, beyond those encountered during normal fueling operations. On this basis, kerosene would appear to present less of a hazard. Once the aircraft is airborne, however, the gasoline vapors in the fuel tanks are too rich to ignite, while those of kerosene fall in the explosive range. In a well designed commercial aircraft, the possibilities of ignition occurring in the tanks while the airplane is airborne are fairly remote so far as we know and, therefore, the hazard arising from using kerosene may not be too serious.

In the case of a crash, there are so many factors, both known and unknown, that have an influence on what can happen that it is unwise to make any statement about the relative safety of the various fuels. There are some investigations under way in this country that may shed some light on fuel fires resulting from a crash, and it is hoped that these studies may point the way toward minimizing the danger.

Cost

When it is realized that approximately one fifth of the total flight operating expense of an airline is represented by the fuel, it can readily be seen why low cost is of such great importance.

The delivered price of a given fuel at the airplane is governed by many factors, chiefly the costs of transportation and handling. For this reason, an actual into-plane price is apt to be misleading. It is usually better to speak in terms of prices f.o.b. tank cars in the refinery area nearest the destination. For example, Gulf Coast prices for aviation grades of gasoline are regularly given in "Platt's Oilgram," a recognized agency for reporting petroleum prices. On this basis, 100-octane fuel is selling from 16.0 to 17.25¢ per gal, but jet fuels are not quoted. However, we know that JP-3 in bulk at the Gulf is priced around 10.0¢ per gal. JP-1 historically is about ½¢ lower. Tightening of the specifications, however, is tending to increase the manufacturing cost and, inevitably, the price to the consumer. This illustrates that it is of the utmost importance to exert every effort to design commercial aircraft turbine engines that can use low-cost fuels already available. Any unnecessary limitations, such as color or abnormally low pour point, should be carefully considered in the light of actual service requirements.

We can say that the commercial operators in America, and I think this goes for the British operators also, want the cheapest fuel available. For safety, they would like it to have a minimum flash point of 110F and have a low vapor pressure.

To conclude, the most economical and efficient fuel for the commercial operators, which also meets their requirements of high flash point and low vapor pressure, is a kerosene-type fuel which will be universally available without the unnecessary expense of extra manufacturing, transportation, and storage facilities.

By E. A. Droegemueller

Pratt & Whitney Aircraft

FUELS must be capable of being delivered to the engine under all operating conditions. This characteristic seems like a very obvious one and yet to meet it, it is necessary to consider the filtering qualities of the fuel.

Ultimately it would seem desirable to eliminate all filters from the fuel system, but with the present state of development of pumps and other components, this can not be done. So, filter clogging is a very real problem.

Studies made by the industry so far indicate that filter clogging is only present with certain kerosene-type fuels. Hydrocarbons tend to freeze out in the form of waxes and clog the filter element, the time required for the clogging varying between fuels.

Consideration of heavier-type fuels always brings up the problem of restarting the engine. The restartability depends a great deal on the characteristics of the engine compressor since it is a function of velocity and pressure at the burner.

Thus, some airplanes can be started better by slowing their speed and allowing the burner velocity to decrease thereby, and other airplanes can be restarted best by speeding up to increase the pressure at the burners by ram. Secondary influences in restarting include the ignition system, how well the burners drain off excess fuel, and nozzle location with respect to plugs.

General conclusion is that the heavier fuels are harder to start (shown from test) but that by good engine design they can be started under all required conditions.

Rapid combustion of fuel requires perfect mixture of fuel and air in proper proportions. This necessitates the best possible atomization of the fuel, but this cannot be obtained without turbulence and gas currents.

A low-boiling-point fuel and high air temperature favor evaporation, and so does high air density, because of the high heat capacity of the air.

Desirability of fine atomization is shown because of the rate of heat absorption of the fuel droplets is proportional to their surface area, and the rate of temperature rise is inversely proportional to the volume of the droplets.

In order to provide good combustion over wide limits of fuel-air ratio, it is necessary to have fuel droplets vary in size with the fuel-air concentration gradient in the burner.

Pratt & Whitney has been trying to develop fuel nozzles that will cover a 50:1 range of flow with a maximum permissible pressure drop of 300 psi. Fuel pump pressure provides a definite limit to this accomplishment in this way: maximum compressor discharge pressure in a medium- or high-pressure turbojet is between 100 and 200 psi. Fuel metering is assumed to require another 100 psi pressure drop. If it is also assumed that 500 psi fuel pressure is available, that leaves only 200 to 300 psi fuel pressure drop for atomization.

If the pumps could operate at higher pressures, better atomization would result. But higher-pressure operation is a matter of metallurgy and lubrication; so far, metals just are not available that will operate at high pressures without adequate lubrication.

Kerosene-type fuel would greatly aid the problem of coordinating the pump, nozzles, and burners.

Although the heavier fuels are cheaper and more readily available, there are limits to the advantages to be gained. For example, tremendous nozzle pressures are required for heavy fuels; in the case of stove oil the figure is 16 times that required for the same flow rate of aviation gasoline.

One nozzle will not give optimum performance for different fuels. Disregarding spray angle and drop size increases, the change from aviation gasoline to JP-1 in a given nozzle configuration resulted in a 40% increase in minimum flow. (Minimum flow is based on the lowest flow at a given pressure for an acceptable nozzle spray, and spray has a direct bearing on the altitude to which good combustion efficiency can be maintained.)

So, it becomes obvious that maintaining good combustion depends on standardizing on a single fuel.

The characteristics of a commercial aircraft turbine fuel felt to be the best balance obtainable for turbine-powered aircraft in their present form can be found in a good grade of No. 1 stove oil or kerosene. This is the type of fuel that would be most satisfactory in P&W's T-34 engine in commercial operation.

Table A shows the properties desired in commercial jet fuel.

Table A—Commercial Jet Fuel Properties

Specific gravity at 60/60	0.820 max
Distillation temperature, F	
10% evaporated	410 max
90% evaporated	490 max
End point	572 max
Loss, %	1.5 max
Residue, %	1.5 max
Viscosity, centistokes	
at - 40 F	10.0 max
at + 100 F	0.80 min
Sulfur, %	0.10 max
Gum, accelerated, mg per 100 ml, (16 hr)	8.0 max
Residue gum, air jet mg/100 ml	5.0 max
Net heat of combustion, Btu per lb	18,500 min
Freezing point, F	- 76 min
Aromatic content, % by volume	20 max
Flash point, F	110 min
Copper strip corrosion	Slight discoloration
Water tolerance	2 ml max
Total acidity	0.10 max
Color shall not be darker than	+ 12 Saybolt
Doctor test	Negative

Wanted – A New Airplane!

BASED ON PAPERS BY

Mel Anderson, Lake Central Airlines

Charles L. Baker, Trans-Texas Airways

T. H. Davis, Piedmont Airlines

James G. Ray, Ray & Ray—Airline Consultants

• Papers: "Passenger and Cargo Service Standards Required for Local Air Service" by Anderson; "Local Service Aircraft and Engines Maintenance Requirements" by Baker; "Wanted—A New Airplane" by Davis; and "Aircraft Ground Handling Characteristics as Required for Maximum Efficiency" by Ray, were presented at SAE National Aeronautic Meeting, New York City, April 17, 1951.

A crying demand now exists among local service airlines for a truly efficient short-haul aircraft. Closest thing to it is the 15 year old DC-3. And the aeronautical engineering profession has long since put whiskers and gray hair on this plane in terms of know-how. The problem today is to get all of this know-how assembled into one airplane, designed specifically for economical operation over short flight distances.

Naturally, there is some difference of opinion but, in general, most local service operators agree that the new aircraft must (1) be able to break even at not more than 50% load factor, and (2) operate at a very minimum direct operating cost per plane mile.

Keeping these two points in mind, these tentative design and performance specifications are suggested for the proposed new plane:

1. Seat 24 passengers at 200 lb per passenger, including baggage.
2. Carry at least 1700 lb cargo—based on cargo density of 8 lb per cu ft.
3. Operating range of 350 miles with maximum pay load.
4. Take-off and land on 3300–4000 ft runways.
5. High cruising speed—at least 200 mph at 4000 ft above sea level, using 50% power.
6. Turboprop engines.
7. High wing design.
8. Tricycle landing gear.
9. Cabin ventilated and heated, but not pressurized.
10. Good ground handling characteristics.

In addition, emphasis should be placed on simplicity in system design, standardization to the highest degree, and maintenance accessibility.

Selection of the 24 passenger capacity brought comments such as these: (1) "Why so much capacity when the average load of all local service airlines today is less than 10 passengers?" and (2) "Why not use the new 40 passenger aircraft that are presently available for just slightly more than it will cost to get a 24 passenger aircraft?" There are several reasons in each case.

Ten passenger equipment would not permit taking care of the peak loads encountered over weekends and holidays. And, at the present fare level of six cents per passenger mile, it is asking too much of engineers to supply a plane that will operate at a total cost of thirty cents per plane mile—or the equivalent of a 50% load factor.

Use of a 40 passenger aircraft would mean carrying around a lot of dead weight—at substantially higher costs. Runway length requirement is another factor dictating against use of this larger plane in local service operation.

On the other hand, revenue of sixty-six cents per mile obtained with an average load of 11 passengers (slightly less than 50% load factor) should cover the total operating costs per plane mile of a 24 passenger aircraft.

The plane should carry at least 1700 lb of cargo, based on a density of 8 lb per cu ft. All cargo space should be located above floor level, and the cargo pits arranged for direct loading and unloading without the aid of lifts or ladders. The cargo door opening should be at floor level.

Requirements call for the operating range to be 350 miles with maximum pay load, including five intermediate stops, with 200 miles plus 45 min reserve at 60% meto power. Increased tankage should permit additional range to be obtained with reduced pay load.

Most operators agree that the plane should have the ability to operate from airports having 3300 ft runways. However, a recent survey indicates that less than 16% of the airports of a representative group of five short-haul airlines have runways shorter than 4000 ft. This raises the question as to how much of a penalty in general operating efficiency and cruising speed should be taken to make available full gross take-off capacity at these airports. The percentage decrease in direct operating

costs per mile with 4000 ft runways should be given full consideration in making the final decision on runway length.

Runway length is directly related to approach speed and landing speed. And, since the lower the landing speed the greater the safety, some way must be found to overcome the cruising speed versus landing speed problem. Such devices as extending flaps of the Fowler type—which increase wing area—are a possible solution.

Cruising speed should be as high as possible, consistent with economy of operation. A cruising speed of at least 200 mph at 4000 ft elevation—using 50% power—is considered a must.

To take advantage of enormous weight saving and smoother operation, it is suggested that the plane be equipped with turboprop rather than reciprocating engines.

Most local service operators prefer a high wing configuration. This type of design would permit use of low-level passenger and cargo entrance doors and eliminate the necessity for a lot of ramp equipment. A high wing also would keep the sun out of the passenger's eyes and make it possible for him to scan the countryside while enroute.

The airplane should have a tricycle landing gear. Among advantages claimed for this type of gear are (1) easier ground maneuvering because the gear is directly steerable, and (2) a level passenger cabin, making it easier for passengers to rise from their seats.

Local airline stops are of short duration but still long enough for the plane to get unbearably hot in the summertime. And use of ground air conditioning units is ruled out because of high cost. Furthermore, altitudes flown are comparatively low so that the airplane does not cool off in flight. Therefore, the airplane should be equipped—at minimum cost—with an efficient, built-in air circulating system. Heaters should also be provided.

Pressurization is not required. The up-and-down flying inherent in local service operation would make it highly desirable, but indications are that costs will rule it out.

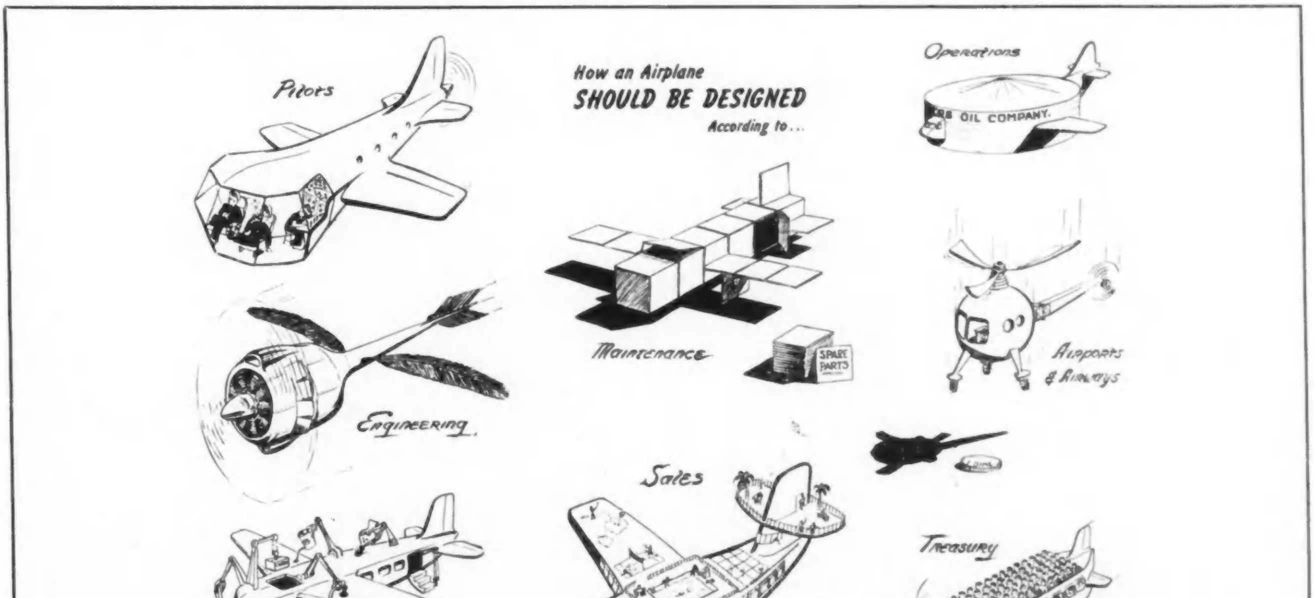
Good ground handling qualities are a necessity. The aircraft should be designed to get through a station with the least expenditure of time and energy. Need for accurate landings (close to the ramp) calls for such flight characteristics as: low landing speed, adequate maneuvering control at approach speed, ability to absorb a substantial amount of drift at landing, and so on.

All loading and unloading of the different kinds of traffic should be done at approximately the same place—near the back of the cabin and behind the wing. To permit faster and safer operation, the cabin door should open out on the same side of the plane as the captain sits and should contain passenger loading steps. Expediency also dictates locating a separate cargo door near the passenger door.

Demand for rapid ground handling calls for refueling the plane from an underground pit (located on the ramp) through an underwing refueling fixture. A door placed in the front part of the fuselage will enable the co-pilot to get out to perform this job. The fuel system should be arranged and operated so that it would never be necessary to refuel into more than one tank.

Maintenance must be accomplished with an absolute minimum amount of work and all parts and accessories should be simple, interchangeable, and easily accessible. Use of the tricycle landing gear and high wing will eliminate the need for a lot of work stands, thereby improving the safety of maintenance operations.

(Papers on which this abridgment is based are available in full in multilithographed form from SAE Special Publications Department. Price per paper: 25¢ to members, 50¢ to nonmembers.)



Courtesy of T. H. Davis, Piedmont Airlines

Design guides developed from in-use data presented. Production Forum—a new feature—outstanding success

Tractor Meeting

"WHAT-HAPPENS-WHEN-YOU-USE-IT" was a dominant theme at the 1951 SAE National Tractor Meeting at the Hotel Schroeder in Milwaukee, Sept. 10-13. Packaged chiefly as guides to designers, use data preempted most of the sessions, beginning with the seven Production Forums which attracted 325 manufacturing men on the opening day. Total attendance for the whole meeting topped 1000—and broke all records.

"What-happens-when-you-use-it" was asked about boron steels at these Production Forums—and steadily throughout the week in informal corridor conversations among the tractor and industrial machinery engineers. Most frequent were questions about application of boron steel to gears. Answers given in many cases reflected the information now appearing in four SAE Journal articles on boron steels in the July, August, September, and October issues.

Conclusions drawn from other "what-happens-when-you-use-it" data during the meeting included:

1. That there is no justification for tractors using rims wider than the standard 13-in. for large tractor tires on dry sand;
2. That air-borne transportability requirements are of increasing importance in design of all kinds of military equipment;
3. That blade strength to the third power provides the best correlating factor independent of soil characteristics in trying to proportion bulldozer blade length to tractive power;
4. That no rational gear design method now exists which considers both beam and surface stresses as well as the effects of sliding action;
5. That rough tractor ride is at least a contributory factor in many ailments suffered by the farmer. One orthopedist has lumped together a whole series of ailments under the general category of "tractor disease."
6. That better formulas and tests are needed to predetermine grader blade design requirements;
7. That future development of side-hitched implements is limited almost entirely to the ability of tires to develop high cornering forces at low slip angles.

In some areas, the engineers found it difficult to lay down specific design guides from study of the use data presented. "So many blade adjustments (on all-wheel drive-and-steer motor graders) are available," one speaker declared, "that it is impractical to set up any formula to determine the frame and tire loading under all conditions." And another, talking of tandem-driven graders, said it's a tough job to eliminate variables from a test which would establish drawbar pull with a given blade pressure. But, he urged, government and other classifications challenge industry engineers to develop such a test. . . Valve life in tractor engines was another area in which the use data seemed to point in a general direction rather than to highly specific conclusions. "Most tractors aren't equipped with hour meters," it was pointed out, "and operator records of fuel, oil, and maintenance leave much to be desired."

In addition to the design-guiding use data which poured from most of the sessions, novel and proven laboratory techniques were described during the meeting, a totally new type of farm vehicle was revealed, and the engineers were treated to a tractor-travelogue story of foreign tractors and equipment.

Wider Rims Not Justified

E. G. McKibben and I. F. Reed of the U. S. Department of Agriculture were the researchers who concluded that users aren't justified in using bigger-than-standard rims on large tractor tires as far as dry sand conditions are concerned. They based their beliefs on tests they have finished recently at the USDA's Tillage Machinery Laboratory. Sponsored by the Tire Industry Advisory Committee, the test results went far to meet the pressing need for data to inform users who have been demanding the wider rims in recent years.

At last year's SAE National Tractor Meeting, for example, one engineer expressed a general feeling when he said: "Farmers don't spend $60 or $75 extra for tire equipment unless they think they are getting some benefits. We are going to need some extremely good proof to convince them that they should stick to the now-recommended rim widths. Either the farmer knows something we don't know—and had better find out—or we are right and must be able to prove it conclusively."

The McKibben-Reed tests so far completed are a good start in the right direction, it was agreed. But discussers emphasized that still more information is needed. Tire men showed themselves still opposed to recommending or permitting use of the wider rims, but some pointed out that even more complete data will be needed before users can successfully be told not to use the wider units.

Breaks Attendance Record

McKibben and Reed explained that they had made these first tests in dry sand because this is one of the most difficult traction conditions encountered in the areas where wider rims are being most promoted locally. (The test plot was 89%, 2%, and 8% sand, silt, and clay respectively.) All-over tread patterns were used. Tests were run at recommended 12 psi tire pressure with static load of 3120 lb and 8 psi pressure with the same load. The static load on the test tire was kept at 3120 lb by adding or removing weights from the tractor to compensate for differences in the rim weights.

Other conclusions arrived at by McKibben-Reed included:

1. Slippage should be kept below 30%. (Maximum drawbar pull and efficiency are obtained at lower values of slippage.)

2. For most efficient operation, slippage should be kept below 20%.

3. Inflation pressure should be as low as possible without causing tire damage.

Airborne Influence Strong

The influence of airborne transportability requirements was shown to be important in connection with the other military requirements stressed by John A. Caldwell, U. S. Army Corps of Engineers, from his knowledge of what happens to such equipment when the military puts it to work. For one hour that military equipment is in actual use, Caldwell pointed out, it is 10 hours in being transported. His whole paper reflected the growing importance of air carriers as a part of military transport.

These and other needs, he showed, may require

They Made the Tractor Meeting Tick

(Left to right) General Chairman S. C. Heth, J. I. Case; Tractor and Farm Machinery Activity's Vice-Chairman for Meetings H. L. Brock of Ford; SAE T&FM Vice-President R. C. Williams, Caterpillar Tractor; and Milwaukee Section Chairman C. H. Duquemin, Le Roi Co.

Around the Meeting . . .

A DAY OF PRODUCTION FORUMS will be held again at next year's Tractor Meeting, SAE Vice-President for Production R. J. Emmert has announced. Emmert—along with Joseph Geschelin, Production Activity vice-chairman for meetings, and M. L. Frey, general chairman of this year's Forums—held an "after glow" session late Monday afternoon with the seven chairmen of the individual Forums. Each reported high interest and good attendance. And each was enthusiastic for repeating the Forums next year. That clinched the decision, which already had been made provisionally by the Production Activity Committee. The provision: that the chairmen and participants in this year's event be really eager to repeat.

* * * *

TRACTOR ACTIVITY COMMITTEE setting up its 1952 Annual Meeting program, took full advantage of its chances to get more and better tractor and industrial machinery papers into SAE publications. It scheduled two papers for presentation by title in addition to those it found room for in its regular session time.

"We see these additional by-title papers as a practical way to better serve all those of our group who don't get to meetings," says T&FM Vice-Chairman for Meetings H. L. Brock of Ford.

* * * *

STORY OF THE MEETING: A salesman and a farmer were seatmates on a long train ride. To pass the time the salesman suggested: "Let's play a game of questions and answers. You ask me a question—and if I don't know the answer, I'll give you a dollar. Then I ask you a question—and if you can't answer you give me a dollar."

The old farmer listened, but shook his head: "No, I couldn't do that. You're a pretty bright young feller. You've got a lot of eddication, I can see. Nup, I'd lose too much on that deal."

"Well, maybe you're right, Pop," the salesman conceded. "So suppose we give you a sort of handicap. I'll pay you a dollar when I don't know an answer, but you pay me only fifty cents when you don't know one."

"Well, ok, Bub, I'll try it on that basis," came the reply.

So, the farmer asked first: "What is it that has three wings, seven legs, and four eyes, but can't fly?"

Stumped, the salesman said: "You've got me there, Pop. Here's your dollar. . . But now let we ask you: 'What is it?' "

"Durned if I know either, Bub," came the farmer's reply. "So here's your fifty cents!"

modification of commercial designs for military purposes—or even "military specials" in some cases. But, he emphasized, the U. S. Army Corps of Engineers favors use of commercial equipment "as is" or modified if necessary as far as earthmoving units for military purposes are concerned. "The last, and certainly the most undesirable procedure," he told the engineers, "is to develop a military special. We don't want them. Not only are they expensive, but they create production problems—particularly when needed in wartime quantity."

Reasons for modifying standard items for military use, Caldwell noted, are many, including: (1) Military transportation needs; (2) Special tactical requirements; and (3) Special environmental conditions. Military equipment must be transported with least possible expense, least possible effort, and must arrive in good condition, he emphasized. This dictates lightweight, high-performance items equipped so they can be loaded, lashed down, unloaded readily, and protected from the elements.

Tactical requirements, he said, dictate radio suppression on all motorized vehicles; better lighting equipment to permit night operations as in daylight; and lightweight earthmovers which can be put into use a few minutes after landed by ship or plane. Armor protection often is another tactical requirement, as is water-proofing . . . and equipment for digging personnel trenches rapidly. High-speed tunneling machines for underground construction and equipment for clearing radioactive areas also is indicated. . . But even on these items, Caldwell predicted, "commercial units may provide solutions."

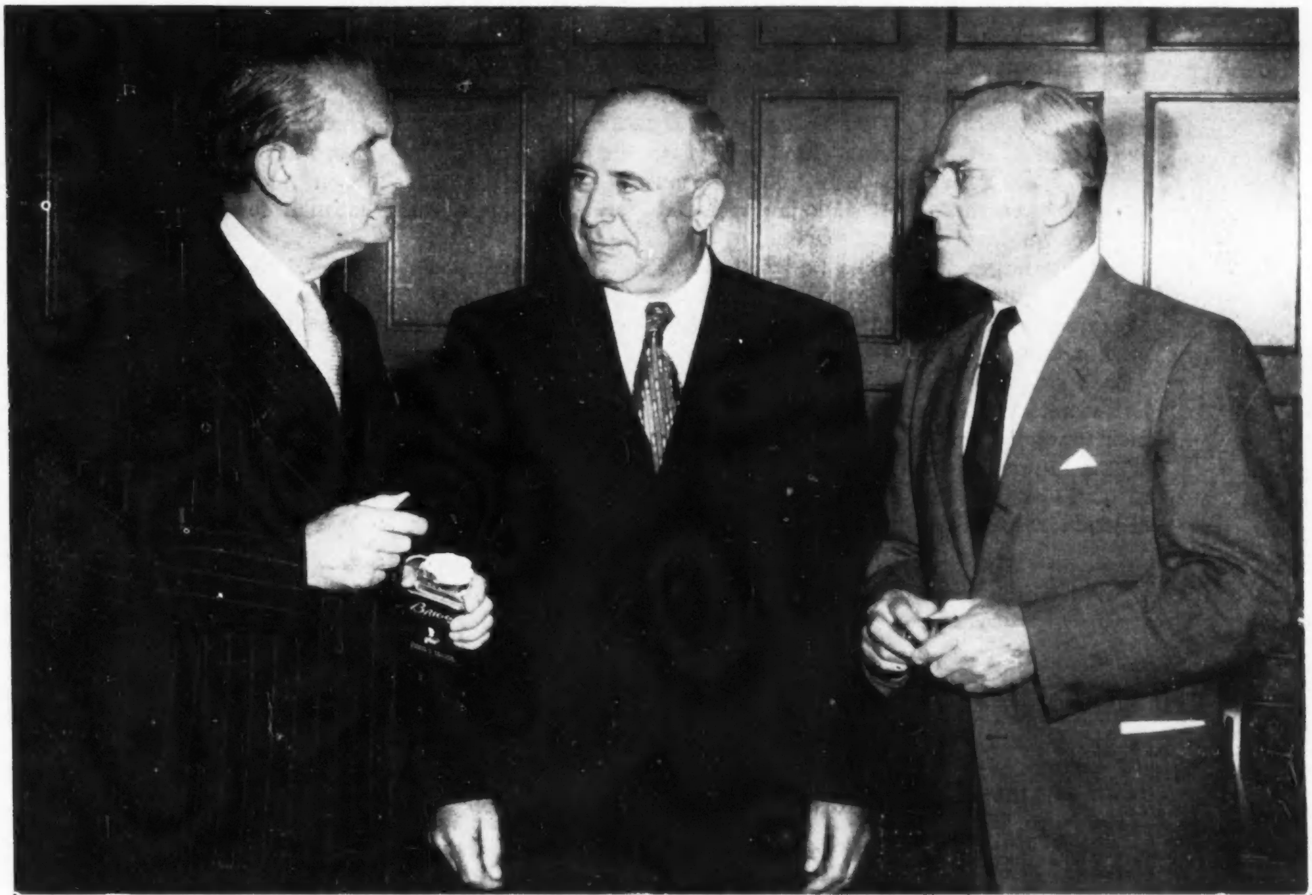
Caldwell paid tribute to important SAE men when he said: "The standardization work being accomplished by the various subcommittees of the SAE Construction and Industrial Machinery Technical Committee is invaluable to the military services."

Gear Design Methods Analyzed

Important design guides suggested by analysis of current practice were given also in the area of tractor bevel gear design. John Deere's Wayne H. Worthington and Kenneth J. Harris took 68 pairs of gears now used by 10 different tractor manufacturers, and summarized the current practice thus revealed in four divisions: (1) basic bevel gear systems in use, based on method of cutting; (2) method of calculation and selection of factors determining the static and maximum tensile stresses; (3) summary of static and maxium tensile stresses, and fatigue life analysis; and (4) materials and heat treatment.

"The wide range of stresses found in comparable positions," they concluded, "reflects the differing ideas and experiences of the individual manufacturers—and the absence of absolute service values. In some cases, the design of bevel gears has been passed by the tractor makers to contract gear manufacturers, and it may be assumed that some designs so provided were unnecessarily conservative. . . Like many other tractor components, where the nature of loading is best determined by experimental investigation than by rational analysis, bevel gear design results in a compromise of good manufacturing practice with the rigorous requirements of field service conditions. As with spur gears, surface con-

Dinner Brought Words of Hope



(Left to right) J. S. Duncan, president and chairman of Massey-Harris Co., Ltd., chief speaker; SAE President Dale Roeder of Ford; and Toastmaster P. H. Noland, Minneapolis-Moline

Ringing words of hope came to listeners at the Tractor Dinner from J. S. Duncan, chairman and president of Massey-Harris Co., Ltd., who was the principal speaker.

"So long as Western Europe is on our side, the free world cannot well be defeated," he assured his audience. "I have just returned from Europe," he continued, "and at no time have I returned from this continent more encouraged with what I saw. The most notable progress has been made in industry. Everywhere in Europe there is a feeling of renewed hope and growing confidence in the future. . . The change in sentiment since the arrival of Eisenhower is quite remarkable.

"But it is not only in the field of rearmament that encouragement is to be found in Europe," Duncan said, going on to conclude:

"There will be no World War III, providing we do not slacken our efforts toward rearmament. Provided, too, that we continue our support of Western Europe and our present policy of ever-strengthening the ties which bind together the United States and the British Commonwealth of Nations. . . The high point of danger is well behind us. . . The turning point, although we did not know it at the time, was when General Marshall announced his plan of Economic Aid at Harvard in 1947. . . War is preventable, if we do but take the right steps at the right time."

SAE President Dale Roeder spoke briefly of the production and engineering problems which face our country today and stressed the important part SAE men can and are playing in their solution.

He introduced to the dinner guests Dr. Daniel P. Barnard, Standard Oil Co. (Ind.), nominee for SAE President for 1952. Dr. Barnard's appearance at this Tractor Dinner, Roeder noted, marked the third time in SAE history that an SAE presidential nominee has made his first appearance in that role at a Tractor Dinner in Milwaukee.

Tractor and Farm Implement SAE Vice-President R. C. Williams, Caterpillar Tractor Co., opened the dinner with a welcome to the guests. Toastmaster was P. H. Noland.

The Production Forum

SEVEN separate panels made up the Production Forum (see pages 77 and 78) which opened the Milwaukee Tractor Meeting events this year for the first time. Attendance at single panels varied from 25 to more than 100 . . . for the day totaled 325.

General Chairman of the Forum was M. L. Frey of Allis-Chalmers. Norman P. Mollinger of Ladish Co. assisted him throughout the arrangements for and operations of the Forum. The Forum was held under the auspices of the SAE Production Activity, led by SAE Vice-President R. J. Emmert of GMC and Production Vice-Chairman for Meetings Joseph Geschelin, Chilton Co.

Discussion and questioning were active at each of the sessions which covered gears, materials handling, quality control, welding, heat treating, forging, and foundry. A vast amount of vital, practical information was given at every one of the sessions, production men in attendance agreed.

Each session was manned by a chairman, his panel of experts, and an official secretary. The secretary made detailed notes of the questions asked and the answers given . . . and their reports of the individual sessions will appear in early issues of SAE Journal.

This Milwaukee Forum, it was generally agreed, reached the same tremendous peak of success which has characterized every SAE Production Forum since inauguration of this type of meeting in Cleveland a few years ago.

tact rather than beam strength needs determine the design of some gear pairs."

No rational design method exists, they said, which considers both beam and surface stresses as well as the effects of sliding action. The need for such an orderly method is great.

Bulldozers and Blades

Other what-happens-when-you-use-it material developed by J. W. Martin and D. B. Folger of Bucyrus-Erie led them to conclude that the criteria of successful bulldozer operation in the field can be met by a wide range of tractor and blade dimensions.

Flotation requirements for any specific soil can be satisfactorily determined, they pointed out, but bulldozers in service do not follow a well-defined trend which can be taken as indicative of typical field requirements. . . And published tractive force data, based on the Nebraska tests, don't give an indication of bulldozer performance, according to these two engineers. Theoretical tractive horsepower (or drawbar pull) is a more representative value, they think, for comparing bulldozer power available for dirt moving.

Neither blade length nor blade area, they say, can be used as a guide in proportioning blade size to tractive power. Blade length to the third power, they urge, provides the best correlating factor independent of soil characteristics. . . A profitable direction for further study, Martin and Folger suggest, is in extensive evaluation of flotation, traction, and blade performance as related to the internal friction and cohesive properties of the soil.

Toward Better Tractive Seats

In another area, interpretation of extensive in-use studies brought from Bostrom's A. K. Simons three suggestions for a scientific aproach to the problem of designing tractor seats. The job the tractor has to do, he pointed out, the position of the seat on the tractor, and the posture of the body in the seat all affect tractor seat suspension design. As a scientific approach he suggested:

1. Record the absolute tractor motion in all three directions simultaneously while the field operation is in progress;
2. Subsequently analyze those records in the light of human tolerances;
3. Design the seat suspension to isolate against the objectionable part of the motion.

Surveys leading up to these conclusions, he said, revealed that the rough tractor ride is at least a contributary factor in many ailments suffered by the farmer. One orthopedist, he said, has lumped together a whole series of ailments under the general category of "tractor disease."

The overall riding comfort problem is somewhat more serious in tractors than in fighter airplanes, Cornell's Dr. E. R. Dye said in discussion of Simon's paper, because the operator's body is supported quite some distance above the center of a throw in a tractor —and its motion is thus amplified. But in an airplane, the operator is seated more nearly on the longitudinal axis through the center of gravity.

And the relation between seat and controls was stressed by Ford's H. L. Brock. No matter how well the seat may ride, he said, if the operation of the controls is difficult discomfort will result.

Other researchers at the meeting revealed that side-hitched-trailed implements present problems of draft that reduce the effectiveness of a tractor and impair the control of the tractor and its equipment. This group, A. J. Wojta, L. O. Roth, and F. W. Duffee of the University of Wisconsin, concluded that design, performance, and future developments of side-hitched implements are limited almost entirely to the ability of tires to develop high cornering forces at low slip angles. A castered wheel design,

The Production Forum

General Chairman of Production Forum M. L. Frey, Allis-Chalmers; N. P. Mollinger, Ladish Co., assisted Chairman Frey; Production Vice-Chairman for Meetings Joseph Geschelin, Chilton Co.; and SAE Vice-President representing Production R. J. Emmert, GMC

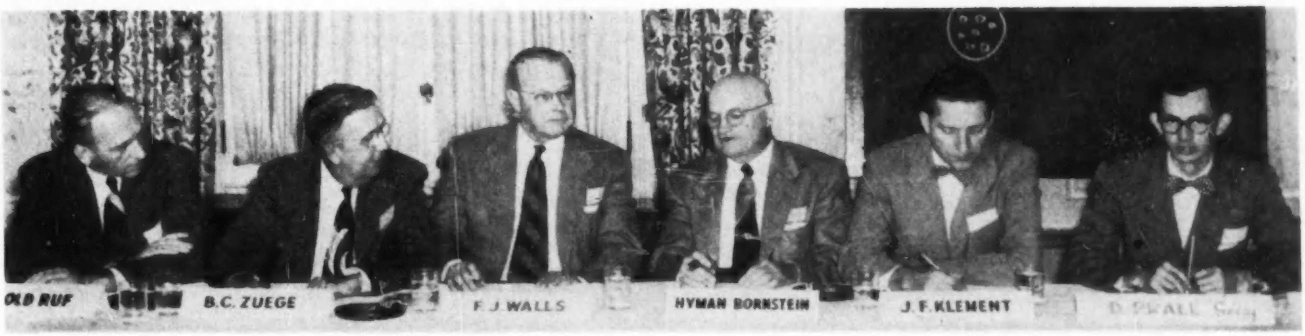
Welding

J. D. Brown, Allis-Chalmers; C. H. Burgston, Deere & Co.; I. R. Bartter, Lincoln Electric Co.; Panel Leader J. J. Chyle, A. O. Smith; C. D. Evans, International Harvester; Kenneth Jackson, Caterpillar Tractor; Mark Hippe, Linde Air Products; and Secretary Francis Brickle, Harnischfeger Corp.

Heat Treating

L. W. Steege, John Deere Waterloo Tractor Works; L. E. Webb, Clark Equipment; Panel Leader J. E. Schoen, Marquette University; J. H. Clark, International Harvester; E. E. Alexander, Caterpillar Tractor; C. I. Wesley, Wesley Heat Treating Co.; and Walter Holcroft, Holcroft & Co. Secretary of this panel was Al Mayer, Marquette University

Foundry



Harold Ruf, Grede Foundries; D. C. Zuege, Sivyer Steel Casting Co.; Panel Leader F. J. Walls, International Nickel; Hyman Bornstein, Deere & Co.; J. F. Klement, Ampco Metals; and Secretary David Prall, Marquette University

The Production Forum

Forging

Secretary Thomas Gialdini, Ladish Co.; Robert J. Exter, Wyman-Gordon; C. E. Stone, Interstate Drop Forge; Panel Leader J. J. Dierbeck, International Harvester; George Daschke, Packard; R. L. Mattson, GMC; and E. O. Dixon, Ladish Co.

Quality Control

Secretary John Santi, Marquette University; E. R. Meyer, Eureka Williams Corp.; J. N. Berrettoni, Dr. J. N. Berrettoni & Associates; Panel Leader H. A. Weissbrodt, International Harvester; Carl Slathar, Minneapolis-Moline; E. L. Fay, Deere & Co.; and W. H. Smith, Ford

Gears

A. S. Black, Fellows Gear Shaper; J. C. Straub, American Wheelabrator and Equipment; N. T. Nilson, International Harvester; Fred Bohle, Illinois Tool Works; Panel Leader B. W. Keese, Timken-Detroit Axle; Charles Staub, Michigan Tool; F. H. Boor, Timken-Detroit Axel; Igor Kamlukin, Allis-Chalmers; B. G. Rich, John Deere Waterloo Tractor Works; and Secretary Donald Rieff, Harnischfeger Corp.

Materials Handling

Secretary Walter Maurer, Harnischfeger Corp.; Emmitt Johnson, International Harvester; B. I. Ulinski, Automatic Transportation Co.; Panel Leader William Naumann, Caterpillar Tractor; J. L. Varga, Ladish Co.; F. M. Blum, Harnischfeger Corp.; and J. C. Webb, Jervis B. Webb Co.

they said, with an ample safety factor for the inner wheel tires, will result in the most stable performance from the standpoint of draft and tractor control.

Grader Blade Design

Specific design guides are hard to lay down from analysis of existing use data in some areas, it became apparent at the meeting. Grader blades on all-wheel-drive-and-steer motor graders seems to be one of these. For instance: "There are many things that happen when you put a motor grader blade in or on the ground," as E. C. Brown of Austin Western Co., said. "So many blade adjustments are available," he pointed out, "that it is impractical to set up any formula to determine the frame or tire loading under all conditions. Under specific conditions, it is possible to analyze the forces on the vehicle or the opposing soil forces at the blade or on the tires."

And H. W. Stoelting of J. D. Adams Mfg. Co., talking of tandem-drive motor graders, said that government and other classifications of motor graders by drawbar pull challenge industry engineers to develop a standard test which will accurately measure one grader's productive capacity against another. It's a tough job, he stressed, to eliminate variables from a test which would establish drawbar pull with a given grade pressure . . . and the Nebraska tests don't accomplish it.

But the challenge should be met, Stoeling urged.

Valve Life Data Insufficient

As regards valve life in tractor engines, too, accurate use data for design guidance are hard to get, it was brought out at the meeting. Ethyl's K. L. Pfundstein and J. D. Bailie, for instance, pointed out that most tractors aren't equipped with hour meters and that operator's records of fuel, oil, and maintenance leave much to be desired. It is recognized, they said, that certain combinations of fuel and oil can affect valve performance, but such effects are not consistent and depend on engine design and operating conditions. "To our knowledge," they stated, "there are no physical or chemical tests which will predict the valve performance of a fuel or oil."

Variability is a fundamental characteristic of valve life, they concluded, pointing out that some engines have the desirable characteristic of being tolerant to variations in fuel, oil, and operating conditions. By design modifications, material selection, and application of valve rotation, these technicians believe, valve life of existing engines can be greatly extended. They believe, too, that the tolerance of an engine to factors affecting valve performance can be improved through such measures.

And Eaton's Vincent Ayres, discussing the valve-life problem, warned engineers not to be fooled by the obvious. "The careful study of valve gear," he asserted, "may show that what is happening at one end of the valve train is the result of something else happening at the other end."

Laboratory Techniques

Laboratory techniques, as well as what-happens-when-you-use-it studies also got attention at this meeting—although the latter type of data predomi-

. . . Around the Meeting

EVERY SESSION CHAIRMAN scheduled to preside was on deck throughout the meeting. Besides those at the Production Forum, they were: G. J. Storatz, J. E. Jass, F. M. Potgieter, H. B. Knowlton, C. L. Zink, and R. K. McConkey.

* * * *

SUBCOMMITTEE REPORTS TO A CIMTC session held during the Meeting revealed a dozen or more new standards in the construction and industrial machinery area are destined for completion in time for the 1952 SAE Handbook.

* * * *

EVERY MORNING AT AN 8 A.M. BREAKFAST, General Chairman S. C. Heth assembled the chairmen and speakers of the day for a pre-session confab. More accurate introductions, more direct stimulation of good discussion and generally smoother operation of every session resulted. The good result of these matin meetings was no surprise. They have almost become a tradition at National Tractor meetings . . . and attendance this year was 100% perfect.

* * * *

SAE COUNCIL MET DURING the week (Sept. 13), made some important decisions. Voted to publish SAE Transactions as a single, annual, bound volume beginning with 1953; to discontinue Quarterly Transactions after 1952 . . . Extended the territory of the St. Louis and Pittsburgh Sections . . . and OK'd establishment of new SAE Student Branches at Carnegie Tech and University of Pittsburgh.

* * * *

THE MEETING WAS OPENED officially by a brief address of welcome from Milwaukee Section Chairman C. H. Dequemin of Le Roi Co.

* * * *

CHAIRMAN C. L. ZINK at the Thursday morning session paid a tribute to L. A. Gilmer, SAE Past Vice-President representing the Tractor and Farm Implement Activity, whose death occurred Sept. 6. The meeting bowed in a moment of silence in memory of their fellow engineer whose life had been so full of fine achievements and warm friendships. . . . Some of the material in the paper by A. K. Simons, presented at this session, had been worked out with Gilmer's help and collaboration.

nated. Goodyear's W. C. Johnson described the construction and operation of a Goodyear dynamometer truck which permits its operator to compute results as the test progresses. This novel instrument has been piling up valuable results since 1946, he said. From its results can be determined the combination of engine power, tire size, load, and pressure which will provide the most effective and economical performance under any operating condition.

Other information about laboratory apparatus was brought to the meeting by John Deere's W. E. Gustin. He described a hydraulic torquemeter and resistance strain gage torquemeter, the aim in design of which was simplicity to provide a most readily understood and accepted means of torque measuring. "Torque fluctuations in a power-takeoff shaft occur so fast," he noted at one point in his description, "that the oscilloscope trace has to be photographed to get an accurate measure of torque peaks. This is particularly true of transitory phenomena such as torque during clutch engagement. This is done with commercial cameras—usually 35 mm—which provide a very small record which must later be enlarged." To get a larger record directly, he suggested, use a device which records the oscilloscope trace directly on sensitized paper. There are several recording oscillographs on the market, he said, whose frequency response is accurate enough to record torque fluctuations. Torque fluctuation during measurement, he stated, can be smoothed out with any type of hydraulic equipment. The hydraulic coupling, however, is not practical because the speed is not maintained from input to output.

Timers, he indicated, can be so operated as to maintain exact frequency. To do this on hydraulic equipment, the timer is driven by a condenser, resistor, and tube combination off a battery. It is checked with a stop watch before the test. . . With the strain gage torquemeter, the frequency of the portable electric generator is adjusted so that it is 60 cycle. This is accomplished by adjusting the speed of the engine.

Both the hydraulic torquemeter and the strain gage torquemeter, Gustin believes, have sufficient advantages so that a farm equipment manufacturer can well afford to use both types.

Under the general chairmanship of **S. C. Heth**, the following served as chairmen of the six technical sessions of the 1951 SAE National Tractor Meeting: **G. J. Storatz, J. E. Jass, F. M. Potgieter, H. B. Knowlton, C. L. Zink**, and **R. K. McConkey.**

M. L. Frey was chairman of the all-day Production Forum. He was assisted by **N. P. Mollinger.**

This report is based on discussions and 13 papers . . . "Bulldozer Power and Dimensions" by **J. W. Martin** and **D. B. Folger**, Bucyrus-Erie Co. . . . "Modification of Standard Earthmoving Equipment for Military Requirements" by **J. A. Caldwell**, U. S. Army Corps of Engineers . . . "Performance Characteristics of All-Wheel Drive Motor Graders" by **E. C. Brown**, Austin Western Co. . . . "Characteristics of Tandem Drive Motor Graders" by **H. W. Stoelting**, J. D. Adams Mfg. Co. . . . "The Goodyear Dynamometer Truck" by **W. C. Johnson**, Goodyear Tire & Rubber Co. . . . "Latest Development in Universal Propelling Unit" by **Martin Ronning**, Minneapolis-Moline Co. . . . "Torque-Measuring Apparatus and Technique" by **W. E. Gustin**, John Deere Waterloo Tractor Works . . . "Current Practice in Tractor Bevel Gears" by **W. H. Worthington** and **K. J. Harris**, John Deere Waterloo Tractor Works . . . "Factors Affecting Tractor Valve Performance" by **K. L. Pfundstein** and **J. D. Bailie**, Ethyl Corp. . . . "Effects of Rim Width on Tractor Tire Performance" by **E. G. McKibben** and **I. F. Reed**, U. S. Department of Agriculture . . . "Tractor Ride Research" by **A. K. Simons**, Bostrom Mfg. Co. . . . "Draft Studies of 'Side-Hitched Implements'" by **A. J. Wojta, L. O. Roth**, and **F. W. Duffee**, University of Wisconsin . . . "Foreign Tractors and Implements" by **R. B. Gray**, U. S. Department of Agriculture.

All of these papers will appear in abridged or digest form in forthcoming issues of SAE Journal, and those approved by Readers Committees will be printed in full in SAE Quarterly Transactions.

The New Uni-Tractor

Something new under the sun was exposed to the view of engineers at this meeting when Martin Ronning of Minneapolis-Moline described a self-propelled carrier on which can be mounted special-purpose elements such as harvesters, cornpickers, and grain windrowers.

The basis of this self-propelled unit, Ronning explained, consists of engine, frame, and so forth—elements which would be common to almost any self-propelled farm machine. Its purpose, of course, is to get around the main disadvantage of the self-propelled specialty machine—namely its high cost in relation to the special and limited-times service it must render.

So far, Ronning indicated, this new unit (which M-M calls a Uni-Tractor) has not been fully discussed from an economy standpoint. Nor has any attempt been made to evaluate efficiency when combined with the specialty elements as compared to conventional equipment. From an economy viewpoint, he said, comparison with a tractor-and-drawn equipment will give one answer . . . a comparison with individually self-propelled machines would obviously give a very different result.

A variable speed drive is used, Ronning explained to a questioner, because it has many advantages, including the fact that with a harvesting unit the speed can be changed quickly under variable crop conditions. The V-belt drive was adopted, he said, because the unit has an engine powerful enough to run the mounted implement and propelling unit—and it wasn't considered practical to build enough strength into the transmission to carry the full horsepower of the engine—as a gear or chain drive would have necessitated. The V-drive cut cost, too, he added.

Tractortour through Europe

Strip-farming and land reclamation (plus Economic Cooperation Administration funds) have increased tractor and farm implement use in Europe since World War II, U. S. Department of Agriculture's R. B. Gray told the engineers at this meeting. (Strip-farming is combining a number of strips of farms so as to make machinery application feasible.)

United Kingdom and Switzerland both have more tractors per arable acre than has the United States, Gray pointed out. Because of gasoline shortages in many countries, most European tractors are diesel-powered. Tractor manufacturers are most active in England, France, Germany, Sweden, and Italy. Some countries like France and Denmark, he said, are reluctant to replace horses with tractors because of possible fuel shortages in event of another war.

Fluids for Hydraulic Torque Converters

THE information in this article has been compiled by the SAE Fuels & Lubricants Subcommittee on Fluids for Fluid Couplings and Torque Converters. It includes material obtained from the Coordinating Lubricants Research Power Transmission Fluid Group.

It is believed that this information will be of interest to users of fluid couplings and torque converters, but more especially to those who are working on new designs involving these units.

AT present the manufacturers of torque converters and fluid couplings for automotive and industrial service, also transmissions, utilizing these devices, differ in their recommendations for fluids to be used in their respective designs. To date, five different viscosity grades are being used. There appear to be sound technical reasons for the employment of these different grades, with little or no possibility for a reduction in their number.

The viscosities of the two lighter grades are as follows: 2.5 to 3.5 centistokes at 100 F, equivalent to 34.4 to 37.6 SUS at 100 F and 60 to 65 SUS at 100 F, equivalent to 10.3 to 11.7 centistokes. These two lighter fluids are used almost exclusively in torque converters of commercial vehicles and industrial units, the lighter one in converters, where neither lubrication nor leakage is a factor to be considered.

The viscosities of the three heavier grades fall in the SAE 5W, 10W, 20, and 20W ranges as defined in SAE Crankcase Oil Classification, revised and adopted Oct. 3, 1950.

Both crankcase oils and specal fluids coming within the SAE 10W range are used for passenger-car automatic transmissions equipped with either torque converters or fluid couplings. This same viscosity grade is also used for fluid couplings of automobiles having standard or semiautomatic transmissions and for some torque converters used in commercial vehicles. One fluid in this viscosity range is widely distributed under the name "Automatic Transmission Fluid, Type A."

For fluid couplings in industrial service, oils in the SAE 10W, SAE 20, and SAE 20W ranges are commonly employed for normal atmospheric temperatures. Oils in the SAE 5W range are recommended by some for subzero service and by one manufacturer for year-round service in a commercial vehicle transmission utilizing a torque converter.

From its test program of hydraulic power transmission fluids, the CLR Power Transmission Fluids Group has developed the following conclusions:

Viscosity: The effect of viscosity on converter performance increases with increasing torque ratio.

Significant differences in maximum efficiency, stall torque ratio, and utility ratio have been shown between fluids designed to have viscosities as identical as possible when measured by conventional laboratory viscosimeters and where one fluid contained a special additive to improve viscosity index, the other using a base fluid without additive. This may indicate that viscosities obtained at low rates of shear in conventional laboratory instruments are not necessarily an indication of the true viscosity of the fluid under actual operating conditions in a converter.

Torque converter performance, as measured by stall torque ratio and utility ratio, tends to reflect the viscosites of the base fluids without additive.

The Power Transmission Fluids Group summarized the opinions of its members regarding the following properties and has published the following available data concerning them:

Specific Gravity: Specific gravity directly affects hydrokinetic transmission torque capacity but, within the range of petroleum fluids, it has no significant effect on efficiency, utility ratio, and stall torque ratio.

Oxidation Resistance: One manufacturer has indicated that the research technique for study of the oxidation characteristics of heavy-duty crankcase oils (CRC designation L-4-949) currently gives the best correlation on oxidation resistance with field service.

Since CRC Designation L-4 introduces factors and conditions not present in a hydrokinetic transmission, it is possible that some other test may be developed which will better reproduce transmission service and also correlate with field test results.

Antifoam Characteristics: At the present time, fluids can be treated in such a manner that foaming is not a problem.

Pour Point: This should be low enough to assure circulation by the pump at the lowest temperature to which the unit will be subjected.

Volatility: Within the range of fluids thus far tested by the CLR group, (min flash point 210 F) variations in volatility resulted in no significant variations in performance due to cavitation, under the test conditions.

Flash and Fire Points: It is not considered necessary to treat these characteristics separately from volatility.

Friction and Wear Reducing Properties Under Boundary Conditions: No specific information is available regarding these lubrication properties.

Corrosion Properties: The fluid itself should not be corrosive and should have corrosion-inhibiting properties. This factor was not evaluated in the test program.

Effect on Seals: The power transmission fluid should be compatible with synthetic rubber. Sealing materials should be selected which will work satisfactorily with the type of fluid needed to meet all the other performance requirements.

Cummins DD Fuel Pump Advantages Described

Based on Paper By

HAROLD H. HALL

Cummins Engine Co.

THE Cummins DD fuel pump is the result of thinking, planning, and work. It is about 70 lb lighter than the standard or single disc Cummins pump.

As in the standard single disc Cummins pump, the number one gear pump delivers fuel from the fuel supply tank to the float chamber. The number two gear pump delivers the fuel from the float chamber through the suction disc to a single master plunger. The metering plunger measures the proper quantity of fuel and delivers it through the discharge discs at the proper time and

Continued on Page 98

1951 SAE National Fuels and Lubricants

Oct. 30-Nov. 1 Drake Hotel Chicago

M. L. Hamilton
General Chairman
Fuels and Lubricants
Meeting

Wednesday, Oct. 31

9:00 a.m. Grand Ballroom

Welcome

M. L. HAMILTON

General Chairman of Meeting

KENNETH BOLDT, Chairman

UNCONVENTIONAL APPROACHES TO FUEL UTILIZATION

Power Booster Fuels for Diesels
—E. J. McLAUGHLIN, P. L. PINOTTI and H. W. SIGWORTH, California Research Corp.

The Humphreys Constant Compression Engine
—W. H. PAUL, Oregon State College, and I. B. HUMPHREYS, The Humphreys Investment Co.
(Display of Car equipped with Humphreys Engine)

2:00 p.m. Grand Ballroom

J. A. NELSON, Chairman

Oil Filtration Problems with High Detergency Lubricants
—H. M. GADEBUSCH, Detroit Diesel Engine Div., General Motors Corp., R. T. KARR, Purolator Products, Inc., and W. B. BASSETT, Lubrizol Corp.

Oil Filters and Additive Motor Oils
—C. W. GEORGI, J. F. O'CONNELL, and T. C. EITEL, Quaker State Oil Refining Corp.

Thursday, Nov. 1

9:00 a.m. Grand Ballroom

W. P. GREEN, Chairman

Some Phenomena of Engine Wear as Revealed by the Radioactive Tracer Technique
—F. C. BURK, L. J. TEST, A. T. COWELL, and H. R. JACKSON, Atlantic Refining Co.

1951 SAE National Transportation Meeting

Oct. 29-31 Hotel Knickerbocker Chicago

F. B. Lautzenhiser
General Chairman
Transportation
Meeting

Monday, Oct. 29

10:00 a.m. Grand Ballroom

Welcome

F. B. LAUTZENHISER

General Chairman of Meeting

W. P. MICHELL, Chairman

Automatic and Hydraulic Transmissions
—O. K. KELLEY, Product Study, General Motors Corp.
(Sponsored by Truck and Bus Activity)

2:00 p.m. Grand Ballroom

J. A. HARVEY, Chairman

Progress of Gas Turbine Truck Tests
—H. C. HILL, Boeing Airplane Co.

Large Conventional Engines for Trucks and Buses
—J. E. GLIDEWELL, Hall-Scott Motor Division, ACF-Brill Motors Co.
(Sponsored by Transportation and Maintenance Activity)

Tuesday, Oct. 30

9:30 a.m. Grand Ballroom

G. W. LAURIE, Chairman

The Impact of Legal Developments on Highway Transportation
—A. C. BUTLER, National Highway Users Conference, Inc.

The Impact of State Size and Weight Restrictions on Motor Transport Equipment
—J. B. HULSE, Truck-Trailer Manufacturers Association, Inc.
(Sponsored by Transportation and Maintenance Activity)

2:00 p.m. Grand Ballroom

B. F. JONES, Chairman

Engine Mountings and Torsional Vibration Dampers for Trucks and Buses
—T. H. PEIRCE and J. B. ROBINSON, H. A. King Co.
(Sponsored by Truck and Bus Activity)

Wednesday, Oct. 31

9:30 a.m. Grand Ballroom

F. E. SANDBERG, Chairman

How Far Should Rugged Individualism Go in Truck and Bus Lubrication Recommendations
—RAYMOND SHAW, The Chek-Chart Corp.
(Sponsored by Truck and Bus Activity)

2:00 p.m. Grand Ballroom

O. A. BROUER, Chairman

Effect of Weight/Power Ratio on Highway Transportation
—N. R. BROWNYER, Timken-Detroit Axle Co.
(Sponsored by Transportation and Maintenance Activity)

Meeting

Engine Wear from Abrasives in Intake Air
—W. S. JAMES, B. G. BROWN, and B. E. CLARK, Fram Corp.

The Availability of Radioisotopes and Their Application to Petroleum and Automotive Research
—G. G. MANOV, Isotopes Div., U. S. Atomic Energy Commission

2:00 p.m. Grand Ballroom

T. A. SCHERGER, Chairman

Early Combustion Reactions in Engine Operation
—E. B. RIFKIN, C. WALCUTT, and G. W. BETKER, Ethyl Corp.

Some Effects of Fuel Structure, Tetraethyl Lead, and Engine Deposits on Precombustion Reactions in a Firing Engine
—WALTER CORNELIUS and J. D. CAPLAN, Research Laboratories Div., General Motors Corp.

Joint Dinner

Fuels and Lubricants,
National Diesel Engine,
and Transportation Meetings

Tuesday, Oct. 30 6:30 p.m. Gold Coast Room

J. E. KLINE
Chairman, SAE Chicago Section

A. T. COLWELL, Toastmaster DALE ROEDER, SAE President

FUTURE ENERGY SUPPLY
C. F. KETTERING
Director, General Motors Corp.

Ladies Invited Informal

1951 SAE National Diesel Engine Meeting

Oct. 29-30 Drake Hotel Chicago

Monday, Oct. 29

9:00 a.m. Grand Ballroom

Welcome

M. R. BENNETT
General Chairman of Meeting

L. D. THOMPSON, Chairman

Design and Application of Diesel Fuel Injection Equipment
—S. E. MILLER, American Bosch Corp.

Effectiveness of Amyl Nitrate in a Full Scale Diesel Engine
—M. J. ANDERSON and G. C. WILSON, Ethyl Corp.

2:00 p.m. Grand Ballroom (Knickerbocker)

The afternoon program of the National Diesel Engine Meeting has been left open in order to permit attendance at the following session scheduled at this time at the National Transportation Meeting at the KNICKERBOCKER HOTEL:

J. A. HARVEY, Chairman

Progress of Gas Turbine Truck Tests
—H. C. HILL, Boeing Airplane Co.

Large Conventional Engines for Trucks and Buses
—J. E. GLIDEWELL, Hall-Scott Motor Division, ACF-Brill Motors Co. (Sponsored by Transportation and Maintenance Activity)

7:45 p.m. Grand Ballroom

R. T. SAWYER, Chairman

Operating Conditions of Railroad Diesel Engines
—E. K. BLOSS, Boston and Maine Railroad

Diesel Locomotive Maintenance
—Lt.-Col. W. C. ROGERS, Transportation Research Development Station, Fort Eustis

Tuesday, Oct. 30

9:30 a.m. Grand Ballroom

D. J. CUMMINS, Chairman

What Is Expected of Diesel Engine Builders in the Foreseeable Future Representing
Construction Industry
—H. H. EVERIST, JR., Western Contracting Corp.
Coal Mining Industry
—H. N. HICKS, Truax-Traer Coal Co.

M. R. Bennett
General Chairman
Diesel Engine
Meeting

Heavy Duty Highway Transportation Industry
—O. A. BROUER, Swift & Co.

2:00 p.m. Grand Ballroom

H. D. YOUNG, Chairman

A Summary of Seventeen Years of Diesel Engine Starting Tests at the U. S. Naval Engineering Experiment Station
—J. F. BLOSE, U. S. Naval Engineering Experiment Station

Sub-Zero Winterization of Diesel Engine Power Equipment
—P. W. ESPENSCHADE, R. C. NAVARIN, and W. W. VAN NESS, Engineer Research and Development Laboratories, Fort Belvoir

HARRY WOODHEAD is now vice-president of Douglas Aircraft Co., Inc., and general manager of the Tulsa Division in Tulsa, Okla. Woodhead's former position with Douglas was general manager of Western Pressed Metals Division, Santa Monica, Calif.

EMERSON W. CONLON, chairman of the department of aeronautical engineering of the University of Michigan, returns to that post this month after having served as technical director of the Air Force's Arnold Engineering Development Center, now under construction near Tullahoma, Tenn., for the past year. During World War II, Professor Conlon was a commander in the Naval Reserve attached to the Bureau of Aeronautics in Washington.

COM. H. J. HUESTER, USNR, is now with the technical group of the Navy's Aviation Supply Office in Philadelphia. For the past three years Commander Huester has been attached to the Aeronautical Standards Group in Washington, D. C. He has been with the Navy's Bureau of Aeronautics in various capacities since 1929.

WARREN D. FOLTZ has joined Timken-Detroit Axle Co., Detroit, as sales engineer. Foltz had been eastern regional manager for Bendix-Westinghouse Automotive Air Brake Co., since 1947, and had been with that company continuously since graduating from the University of Illinois in 1932 except for the war years, when he served with the Army and reached the grade of lieutenant colonel.

LESLIE R. PARKINSON, former chairman of the mechanical and aeronautical engineering departments of Syracuse University, has joined Wright Aeronautical Corp., Wood-Ridge, N. J., as staff engineer. A graduate of New York University, Parkinson did postgraduate work at the same institution and later studied helicopter design at Princeton University. As a lieutenant commander in the Navy during World War II, he was assistant chief engineer of the Johnsonville Modification Unit.

PAUL E. GERY has joined the engineering staff of the new gas turbine division of Lincoln-Mercury Division of Ford Motor Co. Gery was formerly assistant motor engineer for Willys-Overland Motors, Inc., and prior to joining Willys-Overland in 1948 was with various divisions of General Motors Corp. for 18 years.

About

ALEXANDER N. T. ST. JOHN has been elected vice-president in charge of planning and development of Resistoflex Corp., Belleville, N. J. St. John was formerly technical director and research engineer for the company, and will continue to be active in technical development with various Armed Services groups. He is a member of SAE Aircraft Valves, Fittings and Flexible Hose Assemblies Committee.

PAUL HUBER is now manager of test engineering at the gas turbine plant of Ford's Lincoln-Mercury Division in Detroit. Huber was formerly chief test engineer of Fram Corp., East Providence, R. I.

LT. COL. MARLBORO K. DOWNES is now stationed at Andrews Air Force Base, Washington, D. C., where he is chief of structure and grounds branch, Air Installations Division of Military Air Transport Service. Colonel Downes was formerly district airport engineer for the Civil Aeronautics Administration at Byrd Field, Va.

PAUL E. FRIEND has been promoted to New York regional manager of Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio. Assistant regional manager for the past three years, Friend joined Bendix-Westinghouse as a sales engineer in 1946, following four years of service with the Navy.

CHARLES H. KITCHELL is now a design engineer for Hiller Helicopters in Palo Alto, Calif. Kitchell was formerly chief engineer for Cleveland Aero Products, Inc., Cleveland, Ohio.

E. C. BECK, until recently manager of the Detroit office of Sealed Power Corp., has been assigned to special duties in the Muskegon office of the company. He will be replaced by **ROBERT B. HAWKINS**, who has been with Sealed Power since 1940 in Rochester, Detroit, and Muskegon in the engineering and sales engineering departments. **WILLIAM VAN DAM**, who has been with the company since 1938 except for two years spent in the Navy, has also been assigned to Detroit with the sales engineering staff.

Members

LAWLER B. REEVES has been appointed sales manager, U. S. Tires, for the tire division of United States Rubber Co. Reeves has been with the company since 1941 except for service in the Air Force during World War II, when he saw action as a combat pilot. His most recent position was manager of the tire division's government department in Detroit. Reeves' new headquarters will be in New York.

HARDEN B. ELLIOTT, president of Preferred Lubricants, Inc., of Kansas City, Kans., is also serving as plant coordinator for Southwest Grease and Oil Co., Wichita, Kans.

NOBLE SHERWOOD has been made technical advisor to the director of the Aero-Group of A. O. Smith Co., Milwaukee, Wis. He was formerly chief engineer of Clinton Machine Co., Maquoketa, Iowa.

RICHARD P. LOOK is now research engineering designer for Boeing Airplane Co., Seattle, Wash. He is engaged in the design of flight control instruments and special mechanical devices. Look was previously associated with Pacific Car & Foundry Co. in Renton, Wash.

SAMUEL L. SOLA, formerly project engineer and analyst for Rhodes-Lewis Co. of Los Angeles, has joined in the formation of a new company, Larad Engineers, in Culver City, Calif. Larad will offer engineering design and development services to industry in the area.

LT. COL. G. H. WINDSOR is now chief of services branch, Plant and Operations Department, at Wright Air Development Center, Wright-Patterson Base, Dayton, Ohio. Before being recalled to the Air Force, Col. Windsor was manager of government sales for Interstate Engineering Corp., El Segundo, Calif.

C. O. BURGESS, technical director of Gray Iron Founders' Society, Cleveland, is the author of a paper on surface treating of gray iron which will be presented at the International Foundry Congress to be held in Brussels Sept. 14 to 19.

PAUL D. WRIGHT has been appointed conservation officer for the motor vehicle division of the National Production Authority in Washington, D. C. Wright, who was formerly chief automotive engineer for Kraft Food Co. in Chicago, has taken up residence in Falls Church, Va.

C. C. CIPRIANI (left) has been named chief mechanical development engineer of Electric Auto-Lite Co., Toledo, while **H. D. WILSON** (right) was appointed chief chemical engineer. Cipriani has been with the company for 15 years in various capacities, and Wilson joined a predecessor company, Prest-O-Lite Co., 31 years ago, transferring to the engineering division of Auto-Lite in 1938. Promotions were announced by Vice-President **L. H. MIDDLETON**, who was recently appointed director of engineering. Middleton has been in charge of the engineering division for several years.

CLAY P. BEDFORD, executive vice-president of Kaiser-Frazer Corp., has been appointed chairman of the production executive committee of the Defense Production Administration and is deputy chief of the DPA. Bedford has been serving as assistant to defense mobilizer Charles E. Wilson since May, 1951.

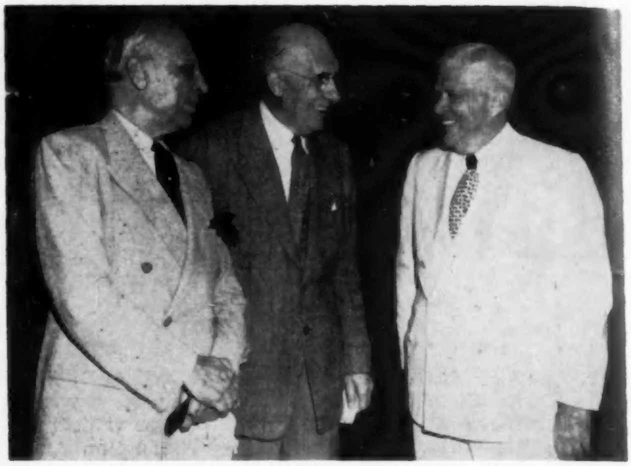
CHARLES J. SOSS has been elected to the new post of chairman of the board of directors of Soss Mfg. Co., Detroit, and is retiring as the company's president. Appointed president in 1940, Soss has served the company continuously since its organization in 1909.

CAMERON M. LUSTY has been appointed director of engineering and sales for Globe Corp. Aircraft Division, Joliet, Ill., with headquarters in Washington, D. C. Before assuming his new position Lusty was chief engineer for Globe in Joliet.

ARMAN E. BECKER, consulting engineer and physicist for the Research division of Standard Oil Development Co., Linden, N. J., retired on Sept. 1 after more than 31 years with Standard Oil. Dr. Becker plans to continue to work on the correlation of physical constants of elements and compounds with particular reference to hydrocarbons, and to write scientific articles for publication. Becker was SAE vice-president representing Fuels and Lubricants Activity when that activity was started in 1933.

"Ket" Honored on 75th Birthday

On his diamond jubilee, Kettering cuts the huge cake at a birthday luncheon attended by 1500



Alfred P. Sloan (left) and Charles E. Wilson (right) congratulate "Ket" on his 75th birthday

CHARLES F. KETTERING was 75 years old on Aug. 29. On that day, industrialists and friends from all over the country joined the people of Dayton, Ohio, in honoring "Ket" in a great exposition and celebration. The guests rode through flag-decked streets to the Moraine Country Club where "Ket" received a testimonial. Responding to his well-wishers, SAE's 1918 President on this memorable occasion said among other things:

"We should be able to fix enough energy from one acre of ground to run an automobile for a year."

"The human race won't get into trouble because it will run out of anything unless it's brains."

"Within ten years, we will be doing with four gallons of gasoline what we did with ten."

"I can't conceive atomic power being used in automobiles, because I can't conceive of it ever being needed in them."

ELLIS W. TEMPLIN has joined the field sales and service engineering department of Timken-Detroit Axle Co. Templin will serve as a special West Coast representative and consultant for Timken-Detroit, with headquarters in Los Angeles. Templin last served as automotive engineer for the Los Angeles Department of Water and Power. He was an SAE Councilor in 1928-29, and vice-president representing Transportation and Maintenance Engineering for 1944.

RALPH F. PEO has been elected to the board of ACF-Brill Motors Co., Philadelphia. Peo is president of Frontier Industries, Inc., Buffalo, N. Y., and is also a director of American Bosch Corp., Arma Corp., and Fairmount Tool and Forging Corp.

FRANK MORGAN, owner of Frank Morgan Co. of Marysville, Calif., announces that his company is now manufacturing and distributing special equipment for the Studebaker Champion engine. The company was formerly a Studebaker dealership.

ROBERT J. MINSHALL, president of the newly created Wooster Division of Borg-Warner Corp., will head operations at a new plant for the manufacture of electrically-driven hydraulic and fuel pumps for jet engines to be built in Wooster, Ohio. Minshall is also president of Borg-Warner's Pesco Products Division and vice-president of Marvel Schebler Products Division.

GLEN C. RIEGEL has been named by the American Society for Metals to lead foreign and American experts in technical sessions at the World Metallurgical Congress to be held in Detroit Oct. 14-19. Riegel is chief metallurgist of Caterpillar Tractor Co., Peoria, Ill.

JACK F. WITTEN, who was formerly chief aircraft inspector at the Naval Air Station at Glenview, Ill., is now an aircraft maintenance specialist for the Navy's Bureau of Aeronautics, Washington, D. C. Witten is technical assistant to the head of the preservation and special projects unit of the Aircraft Maintenance Division.

ROBERT W. KOLB has been appointed chief of fibre research for Dominion Textile Co., Montreal, Que. Kolb was formerly superintendent of Drummondville Cotton Co., Ltd., a subsidiary of Dominion in Drummondville, Que.

FRANK J. HODER, JR., who was previously marine and industrial engine sales manager for Packard Motor Car Co., is now a partner in Hoder and Kellar, a sales company for marine and industrial water pumps and fuel injection equipment in Highland Park, Mich.

C. B. VEAL's new address in Florida is 208 Spring Boulevard, Tarpon Springs, Fla. The address was given incorrectly in the September issue of the Journal.

WARD H. BRIGHAM, who was formerly associated with M B Mfg. Co., Inc., New Haven, Conn., is now with Redmond Co., Inc., of Owosso, Mich., as automotive sales engineer in charge of the western district.

FREDERICK C. CRAWFORD, Thompson Products president, has announced the purchase by Thompson Products, Inc. of the Muskegon Piston Ring Co. The agreement calls for Muskegon holders to receive one share of Thompson stock for each 2½ shares of Muskegon common.

DONALD U. KUDLICH, formerly manufacturing manager at Wright Aeronautical Corp., Wood-Ridge, N. J., is now tank section manager for Anderson-Barngrover Division of Food Machinery and Chemical Corp., San Jose, Calif.

WILLIAM H. KITE, JR., formerly an instructor at North Carolina State College, is now in the special engine research department of Texas Company's Beacon Laboratories, Beacon, N. Y.

Continued on Page 104

JOHN A. LUCAS has been appointed assistant general manager, tire division, of Dominion Rubber Co., Ltd., Kitchener, Ont. Starting in the company's time study division in 1930, Lucas became general manager of the textile division and later general sales manager of the tire division, in which capacity he will continue. Lucas is Vice-Chairman for Kitchener of SAE Canadian Section.

JOHN CRAIG, JR., has been appointed chief of western field engineering for United Aircraft Service Corp., with offices in Los Angeles, Calif. Craig was previously assistant to the president, with special duties on Pratt & Whitney engines, at the company's main offices in East Hartford, Conn.

OBITUARIES

WARREN J. ILIFF

Warren J. Iliff died suddenly on Aug. 21 at the age of 49. He had been suffering from high blood pressure for some time.

Iliff was superintendent of maintenance of Equitable Auto Co., Pittsburgh, Pa. Prior to joining Equitable in 1942 he was associated with General Motors Corp. for many years, having been with Oldsmobile Division in 1933 and 1934 and joining Pontiac Motor Division in 1936.

Iliff served in the Navy during World War I. He was born in Hamilton, Ill., and attended the University of Kansas.

He had recently been elected chairman of SAE Pittsburgh Section for 1951-52. Iliff had served in all offices of the Pittsburgh Section and on many committees.

Iliff is survived by his wife and two sons.

LOUIS A. GILMER

Louis A. Gilmer, chief engineer at the wheel tractor plant of Oliver Corp. since 1942, died of a heart attack at his home in Charles City, Iowa, on Sept. 6. He was 48.

Gilmer joined Oliver in Charles City as assistant chief engineer in 1934. An early advocate of diesel power in farm tractors, he was known throughout the industry for his contributions to the development of efficient power farming. He designed the complete new tractor line introduced by Oliver in 1948, and shared in introducing many features which are now estabilshed farm power applications.

Gilmer held a number of offices in SAE, of which he was a member for twenty years. He was vice-president representing tractor and farm machinery activity in 1949. He served a term as chairman of the SAE technical committee, and was a member of the committee at the time of his death. Gilmer was also a member of the Society of Agricultural Engineers, and had served on the machinery committee and the standards committee. He was also an active member of the Farm Equipment Institute.

He was born in Alamosa, Colo., in 1903 and graduated from the University of Illinois in 1924. He is survived by Mrs. Gilmer and two children.

WILLIAM V. HANLEY

William V. Hanley died last November when his private plane crashed while he and three friends were flying from San Francisco to Northern California for a hunting trip. Hanley was then 41. Wreckage of the plane has only recently been discovered.

Hanley was manager of the aviation division of Standard Oil Co. of California. He joined the company as a research engineer after taking bachelor's and master's degrees at Oregon State College, and remained with the company until his death except for a leave of absence during World War II. He was appointed supervisor of the fuel research engine laboratory in 1938. From 1942 to 1944, Hanley was on leave to the intercontinental division of Trans World Airlines in Washington, D. C., where he served as powerplants project engineer and later chief engineering test pilot. On his return to Standard Oil Hanley was technical representative of the aviation division, and in 1945 was appointed assistant manager of the division.

Hanley was an experienced pilot, holding commercial single and multi-engine land and seaplane licenses. He was a member of Sigma Tau, the Society of American Military Engineers, and was active on the committees of SAE and CRC.

JOHN DAVID GLASS

John David Glass died in an accident July 12 in Indianapolis, Ind. He was 25.

Born in Indianapolis, Glass graduated from Emmerich Manual Training High School, attended Butler University for two years, and graduated from Purdue University in February, 1950, with a degree in aeronautical engineering. During World War II, he served two years in the Air Force. After working for Stewart-Warner Corp. as a salesman, Glass took the first step toward his goal of becoming an aeronautical engineer by joining GMC's Allison Speedway plant as a detail engineer.

Glass was a member of the Junior Chamber of Commerce, Sigma Chi Fraternity, the Columbia Club, the National Aeronautical Club, and was an enrolled student member of SAE. He is survived by his mother, two brothers, and a sister.

CALENDAR

NATIONAL MEETINGS

MEETING	DATE	HOTEL
	1951	
TRANSPORTATION	Oct. 29-31	Knickerbocker, Chicago
DIESEL ENGINE	Oct. 29-30	Drake, Chicago
FUELS and LUBRICANTS	Oct. 31-Nov. 1	Drake, Chicago
	1952	
ANNUAL	Jan. 14-18	Book-Cadillac, Detroit
PASSENGER CAR, BODY, and MATERIALS	March 4-6	Book-Cadillac, Detroit
AERONAUTIC, AIRCRAFT ENGINEERING DISPLAY, and TECHNICAL AIR REVIEW	April 21-24	Statler, New York City
SUMMER	June 1-6	Ambassador and Ritz-Carlton, Atlantic City, N. J.
WEST COAST	Aug. 11-13	Fairmont, San Francisco
TRACTOR	Sept. 9-11	Schroeder, Milwaukee

Baltimore—Oct. 11

Engineers Club. Meeting 7:00 p.m. The Small Gas Turbine for Automotive Use—Clifford E. Roberts, Washington Representative, Boeing Airplane Co. Movies to illustrate Boeing's application and experience in this field.

Buffalo—Date To Be Announced

Inspection trip to Chevrolet plant, but at this time we do not have details.

Central Illinois—Oct. 22

Allis-Chalmers Mfg. Co., Springfield, Ill. Dinner 6:30 p.m. Meeting 7:45 p.m. Plant Layout, Illustrating Uses of Flat Templates and Three Dimensional Models—Harold M. Alkire, assistant to works manager, Allis Chalmers Mfg. Co. Technical paper followed by inspection of planning boards.

Chicago—Oct. 9

Hotel Knickerbocker, Chicago, dinner 6:45 p.m. Meeting 8:00 p.m. The New Studebaker Engine—S. W. Sparrow, vice-president in charge of engineering, Studebaker Corp. Social Half-Hour 6:15-6:45, sponsored by Studebaker Corp. Possibly a display in connection with the paper.

Cincinnati—Oct. 22

Plant visit to the Ford Transmission Plant in Cincinnati, time approximately 8:00 p.m. Meeting is limited to SAE members due to shortage of space.

Cleveland—Oct. 8

Tudor Arms Hotel, Cleveland. Dinner 6:30 p.m. The V-8 Engine—S. W. Sparrow, vice-president in charge of engineering, Studebaker Corp.

Detroit—Oct. 8 and Oct. 29

Oct. 8—Rackham Educational Memorial Building, large auditorium. Dinner 6:30 p.m. Meeting 8:00 p.m. Walker Bulldog—Its Design and Production—E. N. Cole, plant manager, Cadillac Motor Car Division, Cleveland Tank Plant, GMC. Dinner speaker, Wallace Weber, University of Michigan Athletic Staff.

Oct. 29—Rackham Educational Memorial Building, small auditorium. Technical meeting 8:00 p.m. Philosophical Reflections by a Famous Engineer—S. W. Sparrow, vice-president in charge of engineering, Studebaker Corp. Social Hour in the Snack Grille after meeting.

Kansas City—Oct. 1

Rossellis, Kansas City. Dinner 8:00 p.m. Meeting 6:30 p.m. High Volume Earth Movement against the Elements of Time. Speaker from Caterpillar Tractor Co., to be announced. Special Feature: Illustrated by Equipment in Action.

Mid-Michigan—Oct. 6

Owosso Country Club, dinner and dance. Ladies Night.

Milwaukee—Oct. 5

Milwaukee Athletic Club. Dinner 7:00 p.m. Meeting 8:00 p.m. Chrysler Engine—Harold Welch, Chrysler Corp. Social Hour at 6:30 p.m.

St. Louis—Oct. 9

Hotel Gatesworth, ballroom. Dinner 7:00 p.m. Meeting 8:00 p.m. Mind Power Over Man Power—SAE President Dale Roeder.

Southern California—Oct. 18 and Nov. 8

Oct. 18—Rodger Young Auditorium. Dinner 6:30 p.m. Meeting 8:00 p.m. Use of Lightweight Materials and Coordination of Drivers and Mechanics Ideas in Design and Manufacture of Heavy Duty Highway Trucks—Thomas D. Taylor, general manager, Freightliner Corp.

Nov. 8—Rodger Young Auditorium. Dinner 6:30 p.m. Meeting 8:00 p.m. Can Man Survive Prolonged Flights Above 50,000 ft?—Dr. C. I. Barron, M.D., chief of aerial medical department, Lockheed Aircraft Corp.

Southern New England—Oct. 2 and Nov. 8

Oct. 2—Hartford Golf Club. Dinner 6:30 p.m. Modern Highways and Safety—Roy E. Jorgensen, engineering counsel, National Highway Users Conference, Inc.

Nov. 8—Hotel Sheraton, Springfield. Dinner 6:30 p.m. Mechanical Octanes —Alex Taub, consulting engineer, Taub Engineering Co.

Virginia—Oct. 22

Hotel William Byrd. Dinner 7:00 p.m. Meeting 8:00 p.m. Developments and Service on Brakes—P. J. Reese, director of development, Wagner Electric Corp.

Washington—Oct. 16

Naval Ordnance Laboratory. Dinner 1:45 p.m. Meeting 2:45 p.m. Description Mission, Functions and Operations of N.O.L.—Dr. R. D. Bennett, technical director, N.O.L. Welcome—Rear-Adm. W. G. Schindler of N.O.L. Inspection Trip.

Western Weekend Enjoyed By Summer Meeting Guests

SAE Section Meetings

Colorado Group
• R. E. Strasser, Field Editor

The annual summer activity of Colorado Group took place Aug. 17-19 in Georgetown, a picturesque mining town with a long and interesting history about 30 miles from Denver. President Dale Roeder, Mr. and Mrs. Max Roensch of Detroit, and General Manager John A. C. Warner attended, and the guests got into the spirit of the gathering by donning western dress, complete with ten-gallon hats. Horses were available for mountain trips, but most of the members and guests preferred the kind of automotive power equipped with steering wheel and brakes.

A field trip through the Climax Molybdenum Mine at Climax, Colorado proved educational and interesting. The methods and techniques used in mining at Climax were explained, and the trip included a tour through the mill and a view of the open pit operations, where a mountain is actually being moved. John Warner's statement that "so much goes in and so little comes out" was demonstrated to everyone's satisfaction.

Marcellus Merrill, chairman of the Meetings Committee and past chairman of the Colorado Group, and Mrs. Merrill were hosts to the visitors and to the group at their Georgetown cottage for a very enjoyable chuck wagon picnic on Saturday. That evening the meeting was held in the old firehouse of Alpine Company #2 in Georgetown, where Chairman Kenneth G. Custer presided over the meeting and introduced General Manager John Warner and the speaker of the evening, President Dale Roeder. Mr. Roeder reviewed the history of the automotive industry and the development of the modern automobile. He then described the many activities through which SAE is now contributing to the military effort and the future plans for SAE in military work.

Other events of the memorable week-end included a trip over Trail Ridge Road from Grand Lake to Estes Park, and numerous excursions in the mountains, many of which could only be made by jeep.

Gathered for an outdoor breakfast at the Merrill home in Georgetown; (left to right): President Dale Roeder, Mrs. Max Roensch, Lee Elder (standing), Marcellus Merrill, General Manager John Warner, Max Roensch, and George Gromer

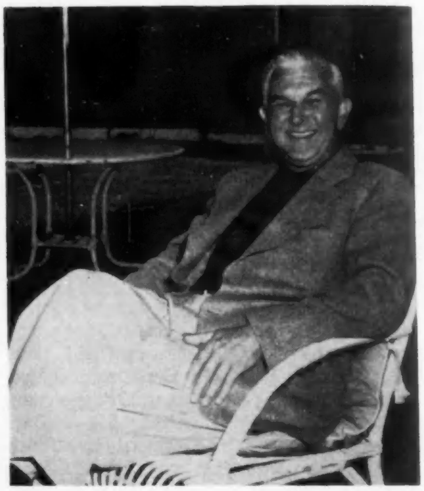
President Dale Roeder and Mrs. Max Roensch were among the guests at the Georgetown meeting. President Roeder addressed members and guests in the local firehouse

Marcellus Merrill, chairman of meetings committee, was host to Colorado Group, August 17-19

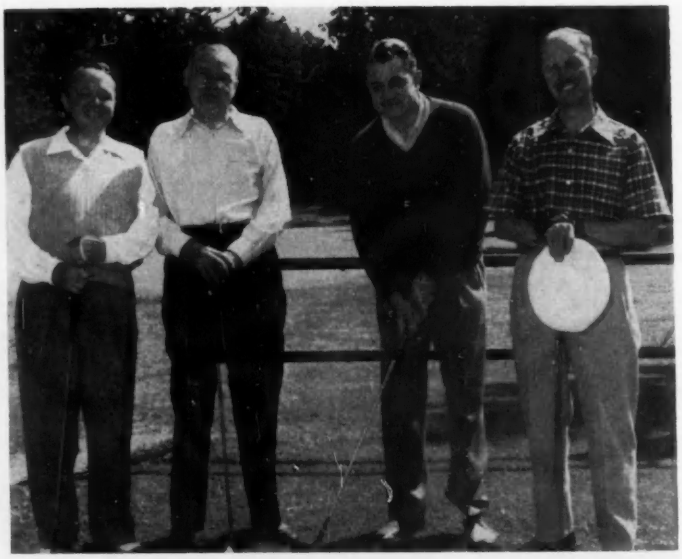
White Sulphur Springs Meeting Hears

Panel of Experts at Boron Forum. Left to right: Roy Roush, Timken-Detroit Axle Co.; Porter Wray, U. S. Steel; T. W. Merrill, Vanadium Corp.; and Chairman M. F. Garwood, Chrysler Corp.

Among the many active on the golf courses was F. W. Marschner (second from left), who was chairman of the Detroit Section Committee which arranged this year's White Sulphur meeting. In this foursome with him were (left to right): D. Gargaro, of Gargaro Mfg. Co.; Marschner; E. J. Rousseau, Commerce Pattern Co.; and Wilfred Williams, Acklin Stamping Co.



Detroit Section Chairman W. H. Graves of Packard relaxes to watch the tennis players after returning from a horseback ride in the West Virginia hills



Among the many foursomes during the meeting were the two pictured here. Left to right: E. P. Lamb, Chrysler Corp.; M. G. Kennedy, Ferro Stamping Co.; W. E. Skinner, Woodall Industries; A. J. Wittlaufer, Wittlaufer Mfg. Co.; W. F. Rockwell, Timken-Detroit Axle Co.; W. A. McKinley, Midland Steel Products; A. C. Chambers, Bendix Products Division; and F. R. McFarland, Packard

Fuels and Boron Forums

Sept. 8—Nearly 250 Detroit Section members and their wives trekked back to Detroit today from their 2nd Annual Detroit Section Summer Meeting at White Sulphur Springs, West Va. Behind them were three days of golf, sports, and social pleasures, and technical sessions on two of the hottest current engineering topics—LPG fuels and boron steels. The weather was fine, the fellowship was warm, and enjoyment high.

Sharing with the SAEer's the historic resort where the Governor of North Carolina first said to the Governor of South Carolina, "It's a long time between drinks," were the Meatcanners Association and the Federal Wholesale Druggists Association.

Fuels Forum

The LPG Forum resembled the best of the SAE Summer Meeting Round Tables with Ethyl's Max Roensch in the chair, flanked by this panel: John M. Campbell of General Motors, Leonard Raymond of Socony-Vacuum, and Stanley Forsythe, chief engineer of Chicago Transit Authority. Forsythe operates the largest fleet of LPG buses in the country (550) in addition to 150 diesel and 800 gasoline buses.

Chief limitations on use of LPG units, it was said, are: (1) available facilities to transport and store such gas and (2) the need for properly controlled and trained personnel—in addition to proper safe-handling equipment. "Propane is as safe to handle as gasoline," Forsythe believes, **"if the proper safeguards are used."**

Comparative mpg and cents per mile figures for gasoline, diesel, and propane operations were given from operator records by several discussion participants. One operation showed: gasoline—3 mpg and 5-plus ¢ per mile; diesel—4 mpg and 3½ ¢ per mile; propane—3 mpg and 3 ¢ per mile. The average of nearly a dozen other operations, it was stated, was: gasoline—4.8 mpg and 5.23 ¢ per mile; diesel—5.67 mpg and 3.73 ¢ per mile; propane—3.93 mpg and 4.56¢ per mile.

The supply of LPG, one discusser said, exceeds the demand by a wide margin and prices of LPG, therefore, should continue relatively low. "Dollars will be the sole judge in each individual case," another speaker concluded, "as to whether gasoline, diesel, or LPG equipment is used."

Boron Forum

The Forum on boron steels on the meeting's second day heard one expert predict that as much as 15 to 20% of alloy steel output may be boron-treated by next January. About 410,000 ingot tons of boron-treated steels have been produced in the U. S. since 1937, it was reported. Production in August 1951 was 21,000 tons and September's projected 35,000 tons will be about 7% of all September alloy production.

It was reported, too, that boron-type steels cost a little more than some of the leanest alloy grades used by car makers, but less than many of the steels currently being used.

Discussers at this Forum confirmed previously noted experience indicating that close control of boron-treated steels during heat treatment is required for best results. Service experience to date, it was said, indicates that when these steels are specified for constructional applications—and are not subjected to temperature effects or corrosion—they offer mechanical properties equal to many steels containing much higher percentages of alloying elements.

Over 300 Make First Tour Of Cleveland Tank Plant

• Cleveland Section
W. B. Fiske, Field Editor

Sept. 10—Starting off the 1951 fall season with a bang, Cleveland Section scored a hit with a tour of Cadillac's new Cleveland Tank Plant and a meeting devoted to ordnance vehicles. The tour marked the first time that a public group was permitted to inspect the plant and its manufacturing operations devoted to the production of Bulldog and anti-aircraft tanks. Only SAE members and applicants were invited, with more than 300 turning out.

Of exceptional interest were the special machines designed to handle the big tank hulls and turrets, performing a multitude of operations simultaneously. Giant 24-foot Betts vertical boring mills and 350-ton Wean grinding machines speed up the manufacturing operations greatly by their ease of handling and automatic performance. Only a year ago, the 53-acre plant, built during World War II, was employed in the storage of agricultural products. Today, it is well organized and turning out tanks at a fast rate.

The meeting program which followed the plant tour was introduced by Cleveland Section Chairman Raymond I. Potter. M. A. Thorne, manager, automotive ordnance group, GMC, discussed "Recent Ordnance Vehicle Developments" and showed movies of the T-51 cross-country carrier and the T-46 amphibious cargo carrier. His presentation covered the performance of these vehicles and some of the engineering problems encountered. Tests demonstrated amazing ability to perform in sand and mud, over the roughest terrain and up grades of 60% and more.

Edward N. Cole, manager of the Cleveland Tank Plant, who introduced Thorne, also told the story of Cadillac's venture in tank-building in cooperation with the Ordnance Department, and pointed to the record progress in setting up and getting the present plant into production.

Coffee speaker of the meeting was Harold G. Warner, assistant general superindentent of the Cleveland Tank

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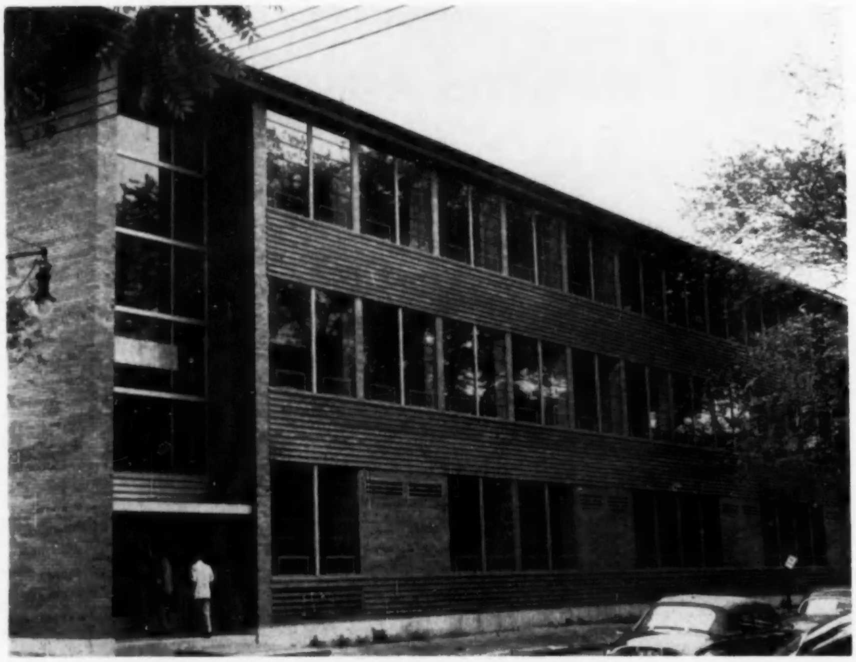
You'll Be Interested To Know . . .

Central Illinois Section Secretary Harlon Banister has announced that the Section's Third Annual Earthmoving Industry Conference will be held April 9 and 10, 1952 at the Pere Marquette Hotel in Peoria.

W. J. Kittredge, Jr., fleet sales representative for GMC Truck & Coach Division, has taken over the chairmanship of SAE Pittsburgh Section, left vacant by the death of Warren J. Iliffe. Kittredge had been elected vice-chairman for 1951-52.



The Wayne Engineering Building, built of steel, brick, and concrete, houses equipment as modern as its exterior. This unit will be only one wing of the completed structure

SAE at

A walk around the urban "campus" of Wayne University in the heart of metropolitan Detroit tells the story of Wayne better than words. Buildings range from the late Victorian to the most modern in functional design, and include a former high school, residences, converted garages and a twelve-story hotel as well as new libraries, classrooms and laboratories of brick, concrete, steel and glass. Everywhere old buildings are coming down to make way for the new.

All this began in 1868, though no one could have seen the comprehensive university of today in the private medical school founded in that year. A few teacher training courses were begun in the same year. Then, in 1917, the Detroit School Board set up a junior college of liberal arts in Central High School. By 1923 this had expanded to a full four-year course and was called the College of the City of Detroit.

Other studies were introduced in response to the needs of the times. By 1930 courses in pharmacy and law were under way, and the college took over all of Central High. In 1933, when the College of Engineering was founded, all the branches of study were united under the name of Wayne University. The Enrollment was 6,400 and growing rapidly.

The city recognized the need of the growing University for classrooms and laboratories, but meeting those needs in the heart of the city was not easy. A single skyscraper was considered and rejected. The plan finally adopted and now being carried out calls for three-story flat-roofed structures of functional design, housing the most modern laboratory, library, and classroom visual-aid equipment.

In 1946 the University broke ground for the program of expansion, and the "streetcar campus" began to take form as a 20th century institution with three new classroom and laboratory buildings, a general and a science library, a twelve-story student center in the former Webster Hall Hotel, and five proposed departmental buildings. The beautiful Engineering Building, one wing of which has been in use for the past year, is nearing completion. Financed by the educational tax fund of the city of Detroit, it houses special equipment for all branches of engineering work, though the unit now in use will eventually be devoted to the mechanical and industrial engineering departments. The rooms include ten test cells for aircraft and automobile engines, a refrigeration room, an electrical laboratory, an industrial engineering laboratory equipped with punch press, lathe, and motion picture camera for use in methods and time study work, two machine shops for making special test equipment, as well as dynamometers and the latest in diffraction X-ray apparatus.

Wayne's new buildings are not ivory towers. The second largest municipal university in the country, Wayne serves the city in many ways. When Ford Motor Co. wanted a program to train supervisors in production management, the university and the company cooperated to establish a part-time five-year course, and the need of training students for the work of industry is never forgotten. Students and faculty alike are active in local offices and factories, and the cooperation of companies, schools, hospitals and civic groups make an important contribution to the education to be had at Wayne.

Professional and scientific organizations have a special appeal to a student body in which so many have already had industrial experience in their chosen fields. The SAE Student Branch serves as an extra-curricular unifying factor among the divisions of engineering, drawing members from the aeronautical, chemical, industrial, metallurgical, mechanical, and electrical engineering departments.

Prior to the spring of 1949, SAE was represented at Wayne by only a few individual student members. In April of that year 32 interested students formed an SAE club, which has more than doubled in membership in the two years of its activity. In January of this year the Branch officially received its charter at a banquet held at Vineyards Inn in suburban Franklin Village. The charter was presented by faculty advisor William J. David. Dean Arthur R. Carr of the College of Engineering addressed the 65 past and present student members, and Homer Strong, director of alumni affairs, spoke on "Human Relations in Engineering." The Student Branch plans to repeat the banquet annually.

Speakers during the past year included Harry Chesebrough, Chrysler Corp., who spoke on "The Engineer and the Automotive Industry"; S. A. Hiersche, Continental Motors Corp., on engine cooling problems; J. C. Hughes, Ethyl Corp., on octane requirements and high compression engines; W. H. Hulswit, U. S. Rubber Co., on "Tire Development Problems"; Eugene Bordinat, Ford Motor Co., on "Styling the Motor Car"; and Merland Kopka of the University's placement office who discussed job opportunities for engineers.

Field trips to the U. S. Rubber Co. production plant, Ford Motor Co. glass plant, Kaiser-Frazer's engine plant, and the Chrysler Corp. research laboratory gave students a chance to view the practical relations of different departments of production to each other.

In the model jet car race held by Detroit Section last spring (SAE

Wayne University

Journal, June, 1951), Wayne's current SAE secretary Ed Solowiej carried off the honors for the best design, while the Chrysler Institute entry won the prize for the fastest car. Elimination trials to choose one entry for each of the schools participating were held at Wayne, using a starting gun designed and constructed by Professor William David, faculty adviser, and Walter Shepherd, past chairman of the Branch. The gun was designed to puncture a gas cartridge and allow the gas to escape in 0.7 sec, giving each car the same amount of thrust for the same period. Since the height of the cartridge varied in the different cars, the whole device had to be of adjustable height.

At the SAE Annual Meeting held in Detroit last January, the Wayne Student Branch joined with other Branches in the area to aid in directing guests to exhibits and conferences. Branch members also served as guides and demonstrators at the University's Spring Engineering Open House.

Though the SAE Wayne Student Branch, like the University's College of Engineering itself, is still in its youth, its activity and rate of growth rival that of many older Branches.

Among SAE Members Who Attended Wayne University Are the Following:

Frank H. Abar, Jr. (**1947-50**), John Arzoian (**1944-48**), Vincent Ayres (**1932-37**), Ernest A. Bacsanyi (**1946-47**), R. C. Balmer (**1937-41**), Charles N. Bell (**1933-35**), Gerald N. Bergum (**1947-51**), E. E. Blasrock (**1926-33**), Rudolph M. Bogre (**1946-49**), E. G. Boudreau (**1937-39**), Edward A. Brass (**1951**), Robert L. Burns (**1950-51**).

Ashton A. Calvert (**1944-45**), Jack L. Campau (**1947-51**), Edgar C. Campbell (**1937-39**), Nicholas P. Christy (**1936-43, 1946-47, 1947-49**), Robert Cliborn (**1934-40**), J. D. Collins (**1944-47**), William Corley (**1938-39**), P. Ken Cummings (**1940-45**), Roman B. Cuzak (**1938-42**), Gerald W. Dalder (**1946-50**), Louis J. Danis (**1933-38**), Henry C. Daum (**1935-37**), Donald K. Davis (**1929-34**), Rudolph J. DeSanto (**1946-50**), John E. DeWald (**1932-48**), Ruth E. DeWald (**1940-48**).

Lawrence J. Easterday, Jr. (**1941-43, 1946-48**), Ralph E. Ford (**1946-50**), Victor E. Francis (**1942-46**), George J. Gaudaen (**1938-42, 1945-47**), Stanley Gecewicz (**1944-49**), R. L. Harkonen (**1929-33**), William Harms (**1936-44**), Donald H. Hartmann (**1947-49**), Charles G. Hicks (**1950**), Edward V. Hindle (**1930-37**), H. Hintzen (**1948**), Stanley R. Hood (**1930-40**), William H. Horn (**1930-35**).

Richard D. Jacobs II (**1939-40**), Fred A. Jenness (**1945**), Harold W. Johnson (**1936-40**), Robert R. Jones (**1937-39**), Robert S. Jones (**1931-35**), Jack Edward Kline (**1933-36**), Sigmund Kloniecki (**1934-35**), Wally Kozlowske (**1948-50**), John A. Krolicki (**1947-51**), Alvin M. Kurz (**1945-49**).

Edwin R. Langtry (**1936-40**), T. R. LaVallee (**1938-42**), Norman Levine (**1946-49**), Carl A. Lindbolm (**1924, 1942**), Anthony Lopucki (**1940-41**), Howard E. Lukey (**1928-30**), Theophil M. R. Lupfer (**1945**), Clayton C. Luther (**1945-51**).

John MacDougall (**1937-41**), Robert Malcolm (**1938-45**), Donald P. Marquis (**1930-39**), Marvin R. Marsh (**1940-42**), E. G. Mathauer (**1926-31**), Edward J. Mazurkiewicz (**1943**), Alexander G. Middler (**1936-41**), Thomas T. Miklaelian (**1942**), Frank Newberry (**1937-40**), Robert B. Newill (**1950**), M. Neumeyer (**1939-42**), N. A. Noreyko (**1935-39**), James Oldham **1950-51**).

Hiram R. Pacific (**1938, 1948**), Leo S. Parry (**1946-50**), Henry C. Parsons (**1933-38**), John Paterson (**1946-51**), Gerald R. Pearsall (**1943-44**), Rex E. Phelps, Lucille Joyce Pieti (**1944-50**), Robert H. Pinney (**1944-45**), Michael J. Plawchan (**1930-32**), Bryant W. Pocock (**1923-24**), Edmund J. Popiel (**1941, 1949-50**), John Edward Quirk (**1938**).

M. D. Rand (**1940-45**), John Redinger (**1933-39**), Albert Resnick (**1936-40**), J. McGill Reynar (**1924-27**), Albert J. Rhodes (**1949**), Earl F. Riopelle (**1938-40**), Arden J. Roberts (**1940**), Jack Melvin Roberts (**1946-48**), A. H. Rosner (**1935-40**), Alexander R. Ross (**1946-49**), E. S. Rowland (**1933-34**).

A. J. St. George (**1925-28**), Edgar T. Schreiner (**1946-49**), A. B. Schultz (**1923-25**), Thomas J. Schultz (**1942-45, 1948**), Donald J. Schwender (**1947-49**), Henry Shabluk (**1934-41**), John P. Sheekens (**1944-46**), Donald D. Simpson (**1921-23**), John J. Smith (**1936-49**), Robert H. Smith (**1944-48**), Milo W. Snider (**1935-41**), Frederick A. Stewart (**1942-48**), David A. Stoddart (**1940-47**), Gordon R. Stone (**1938-42, 1946-49**), J. H. Stone (**1938-46**), E. C. Storms (**1922-23**), D. O. Stovall (**1929-33**), Walter E. Strasser (**1926-30**), Leopold T. Szady (**1935-40**).

Philip W. Tabb (**1936**), Herbert W. Templeton (**1935-38**), Glenn W. Thebert (**1946-50**), Donald B. Tipping (**1946-50**), M. C. Turkish (**1934-38**), C. H. Turnquist (**1928-34**), Albert F. Vandenbergh (**1933-39**), Edgar J. Van Dyk (**1931-36**), Albert F. Welch (**1948-49**), Bernard A. Wilkie (**1946-50**), Christian H. Will, Jr. (**1937-42**), W. Eric Wilson (**1935-37**), Robert G. Wingerter (**1934-35**), Richard L. Zenker (**1946-47**).

Officers of the Student Branch for 1951-52 inspect a CFR engine used in determining the cetane number of diesel fuel. Left to right: Edward Solowiej, secretary; Merle B. Easter, chairman; Louis Tubben, vice-chairman; and Arthur Larsen, treasurer

25 Years Ago

Facts and Opinions from SAE Journal of October, 1926

Comments on the first bound issue of the SAE Handbook made by J. B. Armitage—from a Mechanical Engineering review: "The SAE Handbook is probably the most successful means used to date to get the standards adopted by an engineering society into the hands of the user, and it is undoubtedly responsible for a large part of the success of the SAE standardization program. The new bound-volume edition should prove even more valuable to the membership, for the user can now be sure that his book is up-to-date and that he is not using a standard that has been changed or has become obsolete, for the SAE Standards do change."

H. L. Horning opinions expressed at an Indiana Section meeting: Six cylinder engines are best for passenger cars; eights are legitimate for racing cars and aircraft. . . . No need exists for transmission of engine vibration to chassis; insulation from such vibration probably can be accomplished by some form of spring suspension. . . . Great progress has been made in the last few years toward solving lubrication difficulties.

■

When operating with kerosene blends, the fluid film apparently breaks down and unstable lubrication begins under less severe operating conditions than when straight mineral oil is used—S. A. McKee, Bureau of Standards.

At one time the Hudson Motor Car Co. thought a speed of 3 ft per min for a car-assembling track, with an average of two men working around the chassis or assembled car, was about right. Experimenting proved that the speed could be increased to 12 to 15 ft and the number of men to six or eight without affecting the quality of the work. Where formerly 350 cars were got off the line in 9 hr, they were finally able to get 1180 cars out.—V. P. Rumley, Hudson Motor Car Co.

■

The most important part of our gaging system is the human element, according to R. R. Todd of the Oakland Motor Car Co. Development of an instrument that will indicate or register noise in a practical way will be one of the greatest assets to modern mass production.

■

Although much improvement has been made in various phases of the gear problem, a complete solution has not yet been reached.—R. S. Drummond, Gear Grinding Machine Co.

■

Regarding supercharger development for passenger cars, C. R. Short of General Motors Research suggests the possibility of designing a supercharger that will produce greater torque at low speed. C. F. Taylor of MIT says, "Optimism in regard to supercharging passenger car engines is evident, but very little is known about it."

Section News

Continued from Page 91

Plant, who discussed "An Engineer's Reaction to a Planned Economy." Warner told of his observations and experiences in England and the manner in which material resources are controlled by allocation and planned disposition. Nationalization, he said, is the first step toward a planned economy, and he pointed out the dangers of losing our free enterprize system if we are not vigilant. Controls today put us on dangerous ground, he believes.

Air Force is Host At Tour of Hickam Base

Hawaii Section
• D. H. Mikkelson, Field Editor

Aug. 20—The Air Force was host to Hawaii Section at a meeting held at Hickam Air Force Base. Col. W. J. Campbell, Commanding Officer, 1500th Maintenance Squadron, George Miller, Superintendent of Shops, and Franklin Leensvaardt, Chief of Production Control, arranged a complete tour of the repair shops which handle all phases of aircraft maintenance from the C-97 Stratofreighter with its 4360 engines down to the smallest instruments.

After the group had inspected a C-97, Capt. John Vollstedt, Engineering Officer, 1266th Air Transport Squadron, spoke on the performance and operation of the plane and the 4360 engine. Lt. Margaret Perry, Flight Nurse, 1453rd Medical Air Evacuation Squadron, gave a brief talk on the duties of a flight nurse and the technique of air evacuation of the wounded.

Maintenance Can Prevent Diesel Crankcase Explosions

• Metropolitan Section
Charles Foell, Field Editor

Sept. 5—Better maintenance and operation practices will reduce diesel engine crankcase explosions, **G. W. Ferguson,** The Texas Co., concluded in his presentation of extensive laboratory work on lubricating oil aspects of this phenomenon.

No appreciable differences were found in the flammability of a wide range of lubricating oils generally used in diesel powerplants.

The cause of these explosions appears to be caused only by some overheated part which, because of poor maintenance, is permitted to stay hot, he reported. Normal operating diesel engine temperatures are below the flashpoint of the oil mist and oxygen vapor in the crankcase.

Crankcase explosions are usually self-contained in the automotive type high speed diesel unit because the strength-to-output ratio is usually high enough to prevent serious damage. The truck or bus operator can feel the contained explosion and stop the engine until it has cooled off.

Marine and stationary engines of large horsepower output have a relatively low strength-to-power ratio and

seldom have the constant attention which a vehicle driver gives his equipment.

A. C. Cavileer of the Naval Engineering Experiment Station, Annapolis, described work done by the Navy to indicate the imminence of an explosion and to minimize its effects should the indicator fail to indicate or be too late in reporting pressure buildup in the crankcase.

Ferguson was of the opinion that refinements in engine design might be the most effective attack on this problem.

The report of this investigation summarized 104 serious explosions during the past decade. Most explosions gave outward signs of trouble, such as puffs of white smoke from around crankcase doors and openings or excessive vibration and noise, but a few cases showed no such clues.

Technical Chairman of the meeting was Harold A. Strohman, Cummins Engine Co., assistant to Niilo V. Hakala, Diesel Vice Chairman.

Among those present at this meeting were twelve Metropolitan Section Past Chairmen, including W. P. Kennedy, who served during the Section Year of 1911-12, the year the Section was organized. He was among the founders of SAE in 1905.

Other Past Chairmen introduced by Section Chairman J. Edward Schipper, Jr., were Carl F. Scott, who was the 1918-19 Chairman; Walter S. Peper, 1933-34; S. G. Harris, 1934-35; Sydney G. Tilden, 1937-38; Merrill C. Horine, 1938-39; T. L. Preble, 1939-40; Herbert Happersberg, 1942-43; William E. Conway, 1946-47; Richard C. Long, 1948-49; Richard Creter, 1949-50 and E. N. Hatch, 1950-51.

Past Chairman Hatch received a scroll from the SAE Council in recognition of his services as Section Chairman during the past Section Year. Secretary and General Manager John A. C. Warner was given an ovation when introduced.

"Little Henry" Helicopter Shows Its Virtues in Movies

• Williamsport Group
Allan Creighton, Field Editor

Sept. 10—Forty-five members and guests inaugurated the 1951-52 season with a buffet supper at the Minnequa Boat Club and a special welcome to 14 new applicants for membership. High point in the program was the showing of McDonnell Aircraft Corp. colored movies detailing construction, testing, and operation of the Voo Doo penetration jet fighter, the Banshee carrier-based jet fighter, the Phantom twin-

t carrier-based fighter, and the Little enry ramjet helicopter. Particular nterest centered on the Little Henry nd those present were surprised by its mplicity of design and the following eatures:

- Extremely lightweight (280 lb empty).
- Freedom from the complication of clutch and transmission installation.
- Freedom from torque reaction and the necessity for torque compensating devices.
- Performance and easy maneuverability.

It appeared to those present that the ramjet 'copter in mass production offers vast possibilities for a low cost article easier to fly and cheaper to maintain than other types of rotary-wing aircraft.

Northrop Aeronautical Institute

The NAI Student Branch opened the season with a dinner meeting at the Western Avenue Country Club on Sept. 7. More than 80 attended.

Alexander T. Burton, vice-president of North American Aviation, Inc., spoke on the future of the young engineer. Burton pointed out that as aircraft have become more complex the number of engineering man-hours per plane has increased tremendously, and gave rough figures of the time needed in working on the P-51 and the F-86. The advent of jet planes has increased the need for technically-trained men twofold.

Burton described the solution of one engineering problem of the F-86D. Ice on the radar dome of this plane was causing poor transmission. Various methods of correction were tried, and eventually the problem was solved by a heated air arrangement, consisting of three layers of fiberglass and one each of a honeycomb and fluted core in a sandwich construction on the nose section, which distributes hot air over the entire surface. Some 6,000 man-hours were spent in the solution of this problem. As long as new planes present new problems, the demand for trained engineers will continue.

Burton predicted a bright future for graduates in all fields of engineering. The holder of an engineering degree has an initial advantage in getting a job over the man with technical training but no degree, he felt, but stressed that once on the job advancement depends upon performance.

Chairman Eugene Smith announced the results of the election for new officers of the Student Branch. Bruce Bearden is the new chairman, Mark Donahue is vice-chairman, Jack Brown is secretary, and John Dunstan is treasurer for 1951-52.

Continued from Page 81

at low pressure to the injectors. The major difference in the double disc DD pump, in this portion of its operation is that the latter has two sets of discs and covers.

It also has a mechanical governor which limits the maximum rpm and controls the idling. It has eliminated many of the reversals of direction of forces which existed in the single disc pump—and thus obtained a better performance characteristic.

Advantages of the DD pump include: lighter weight, smaller physical dimensions, and longer life. (Paper, "New Developments in the Diesel Engine Field," was presented at SAE Northwest Section meeting, Nov. 3, 1950. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

CAA Jack-of-All-Trades in Civil Aviation Areas

Excerpts from Paper By

E. N. Morey

Civil Aeronautics Administration

THE Civil Aeronautics Administration is a jack-of-all-trades in aviation. It regulates and it promotes flight activity. It operates a great network of flying aids—and develops many new facilities. It helps build thousands of airports, and operates one model field. It is responsible for little communication shacks at isolated locations . . . and for powerful radio centers whose signals are heard by aircraft all over the world.

CAA is a grass-roots agency, too. It has 10 employees serving the public in the field for every one in Washington. Since 1926, it has tried to help American aviation. And perhaps the best evidence of the successful accomplishment of its assigned tasks is the growth of the industry from a struggling infant to its present stature.

Together, the CAA and the Civil Aeronautics Board have the responsibility for fostering the development of civil aeronautics, keeping in mind its importance to the national defense and the postal service. (Paper, "Government Responsibility in Aviation Safety," was presented at SAE Mohawk-Hudson Group meeting, April 11, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Rotating Valves Increases Valve Life

Based on paper by

A. L. POMEROY

Director of Development, Thompson Products, Inc.

EXTENSIVE laboratory and field tests confirm the value of rotating valves. Sticking and gumming of valve stems and flaking of face deposits preclude good valve seating and lead to hotter valves. Valve rotation copes with deposits and also alleviates the temperature problem.

Benefits which can be obtained by rotating valves are:

1. Stem and guide are kept free of deposits, thereby preventing sticking—a common cause of valve burning.

2. The wiping action imparted between the valve face and valve seat

prevents buildup of deposits which could flake off and allow blowby.

3. Prolonged exposure of any one sector of the valve face to a local hot spot on the seat is avoided. This, in turn, results in lower and more uniform valve-seat operating temperatures.

A number of different types of valve rotators are being used at the present time. One design is so arranged that forces inherent in the valve train induce rotation when the spring retainer frees the valve from the spring force. Another device, in itself independent of engine and valve train vibrations, provides positive, controlled valve rotation. With a third type, rotation is nonpositive and occurs as a result of vibrations encountered in the valve mechanism.

Tests have shown that valve rotation is applicable to all types of engines and can result in two to five times increased valve life. In many cases valve life improvements obtained through rotation are additive to those incurred through design operational changes. Rotation also paves the way for realizing the benefits of compounded oil without incurring the penalties which often accompany the use of it.

Other secondary benefits are obtainable through valve rotation. It distributes what lubrication is present around the valve stem diameter and prevents the condition of metal-to-metal contact that is usually responsible for valve-stem scuffing. Valve guide wear can be reduced by rotation. Rotating the valve prevents undue tip wear, eliminating the localized wear frequently found with non-rotated valves in overhead valve engines.

(Paper, "Valve Rotation—Its Impact On Engine Design and Operation," was presented at the SAE Mid-Continent Section Meeting, Oklahoma City, March 23, 1951. It is available in full in multiliothographed from from SAE Special Publications Department. Price: 25¢ to members, 50¢ to nonmembers.)

Turbine Problems in Transport Operations

Excerpts from Paper By

J. G. BORGER
and
R. W. BLAKE
Pan American World Airways

THE turbine engine is on its way to transport use. But let's appreciate the cost problem beforehand, so we can all try to do something about it **before** the engines are placed in operation—not afterwords.

Military experience is not necessarily a good guide for commercial operations. Every reciprocating engine introduced into commercial service since World War II—each with a good military reputation behind it—has had to go through a debugging period for a year or two before it has been accepted as satisfactory for commercial operations. What evidence is there that the turbine engine will be any different?

Most of the bugs that have appeared in reciprocating engines have shown up after the first 500 to 800 hr. This is the big difference between military

and commercial operation. In commercial operation, greater stress is placed on part life, because it can be most important in reducing costs.

There seems to be a school of thought that the turbine engine will solve all the operator's problems. Strangely, many competent engineers have adopted the ostrich-like thinking that: "Since it hasn't happened, it won't happen." No one would be happier if this were the case than the airline operator. But if the turbine engine is so simple and foolproof, why isn't the maximum overhaul period more than 600 hr? Why don't more engines reach approved limits? Why aren't turbine engines cheaper? Why isn't one of the most experienced turbine manufacturers (Rolls-Royce) willing to warrant parts for more than 1500 hr when reciprocating engines carry 2500 to 4000 hr guarantees?

The total experience in commercial operation with the turbine engine is 13[illegible] hr. This was accumulated in the summer of 1950 by British European Airways on a Vickers Viscount equipped with Rolls-Royce Dart turboprop engines. What appears to be far more interesting to the operator is the plan of British Overseas Airways Corp. to operate a DeHavilland Comet on a longer proving period—to determine just what are the requirements for operation of a jet aircraft.

Turbojet Poses New Problems

The turbojet airplane introduces many problems new to airline operation, not only because of high speeds, but because of reserve requirements, approach procedures, high altitude operation, and lower tolerance to navigational errors. These are the most complex, and their efforts cannot be evaluated until some experience is gained. That is why BOAC is undertaking the proving program with the Comet, which was delivered in April, 1951.

But just because we, as yet, don't know how to evaluate these effects, we should not underestimate them.

American Proposal

The proposal of American manufacturers to approach the transition to turbine engine transports cautiously will serve to ease the problem—and the costs—to the operators. But until an airline can count on overhaul periods approaching those for reciprocating engines, and corresponding parts life, we fear that the turbine engines will be more expensive to maintain than the reciprocating engines. Moreover, it does not appear that payloads will be appreciably better, since they are already limited by fuselage volume for most ranges. Thus the cost per ton mile will be similar to the cost per mile.

Fuel costs will be entirely dependent on development of fuel consumption and the price of fuel. Since fuel cost will unquestionably be the largest single item of the direct operating cost, here is the most productive field for reducing turbine aircraft operating costs below the reciprocating plane's.

There is no question in our minds that the overall operating cost per hour of the turbine engine will be higher than the reciprocating engine counterpart. We fear that for some time to come, both cost per mile flown and cost per ton mile will be higher. (Paper, "Influence of Turbine Engines on Transport Operating Costs," was presented at SAE National Aeronautic Meeting, New York, April 16, 1951. It is available in full in multilithographed form from SAE Special Publications Department. Price: 25¢ to members. 50¢ to nonmembers.)

Personals

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EVERETT H. SCHROEDER has been appointed general manager of Franklin Machine Products Co., Inc. Schroeder was formerly president of Aircraft Maintenance International, Inc.

NEIL M. HURRY, formerly sales manager for Marvel-Schebler Carburetor Division of Borg-Warner Corp., is now general sales manager of Autopulse Corp., Ludington, Mich.

CHESTER L. CARLTON, who was chassis engineer with General Motors Holden's, Ltd., in Melbourne, Australia, is now at GMC's technical center at Warren, Mich.

ROBERT L. DOUGLAS has joined the regular common carrier conference of American Trucking Associations, Inc., Washington, D. C. He was superintendent of maintenance with California Truck Rental Co. of Los Angeles.

WILLIAM J. McCURDY, formerly with the research department of United Aircraft Corp., East Hartford, Conn., is now at Massachusetts Institute of Technology doing graduate work in aerodynamics.

JOHN M. MITCHELL, who was formerly associated with Industrial Products Division of Firestone Tire & Rubber Co., is now a chemical engineer at the Fostoria works of National Carbon Division, Union Carbide & Carbon Corp., Fostoria, Ohio.

MARION F. SMITH is now a research and development engineer with ACF-Brill Motors Co., Philadelphia, Pa. He was formerly an independent consulting engineer.

GARRETT DUANE SHAW of Pacific Car and Foundry Co. is now with the Chicago office of that company as eastern field engineer. He was previously in the tractor equipment division at Renton, Wash.

CAPT. IDAN E. FLAA, who is associated with Ethyl Corp., Detroit, Mich., is on military leave of absence to the Ordnance Corps. Captain Flaa is working on tank design and production as a project officer in the research and development division of Detroit Arsenal, Centerline, Mich.

JOHN R. GRETZINGER, formerly oil filter engineer with AC Spark Plug Division of General Motors Corp., Flint, Mich., is now assistant chief engineer at GMC's Buick-Oldsmobile-Pontiac Assembly Division in Kansas City, Kansas. He will aid in the administration of an engineering department being set up to produce the Republic F-84-F Thunderjet fighter plane.

J. R. CANNON, who was formerly in Washington, D. C., with United States Rubber Co., is now at the company's offices in Dayton, Ohio.

GORDON P. DENEAU is now the owner of Deno Engineering Co., Birmingham, Mich. Deneau was previously with Chrysler Corp. in Detroit.

D. MARSHALL KLEIN, who was a powerplant engineer with the Civil Aeronautics Administration, has been named general sales coordinator at Curtiss-Wright Corp., Caldwell, N. J.

JOHN P. TARBOX retired on July 1 as executive staff engineer for Budd Co., Philadelphia, Pa. Tarbox will continue to live in Philadelphia at 7216 Wayne Avenue.

FORREST K. POST, who was president of Clutch and Transmission Service, Inc., Minneapolis, Minn., is now sales service engineer for Rockford Clutch Division of Borg-Warner Corp. in Rockford, Ill.

A. ALAN MONTROSE, formerly a development designer with McKenna Design Engineering Co. in San Diego, Calif., is now an aircraft jig tool designer with Boeing Airplane Co., Seattle, Wash.

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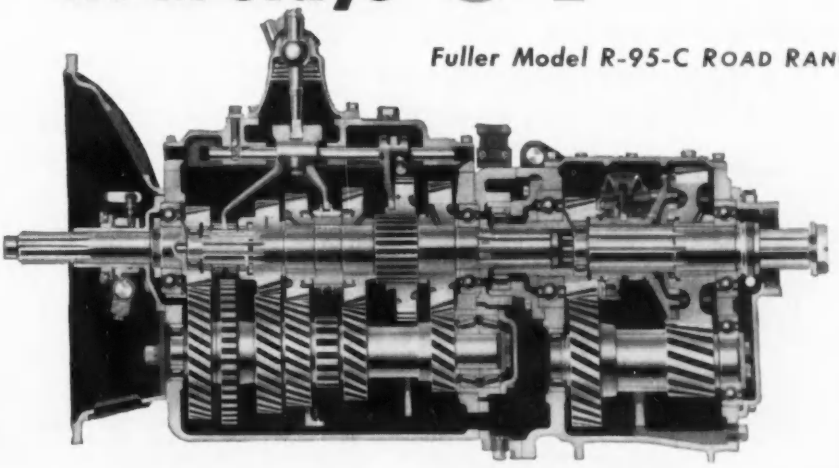
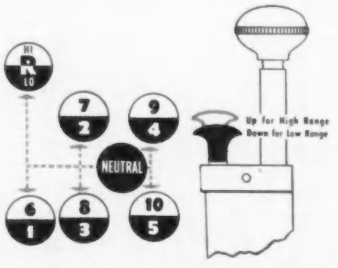
Your TRIP Costs go DOWN when RPM stays UP



Fuller Model R-95-C ROAD RANGER

FULLER ROAD RANGER®



With a new Fuller ROAD RANGER Transmission in your rig, you can pull the same load *faster* with *less fuel,* or a bigger load with the same amount of fuel.

One look at the shift diagram above for the Model R-95-C shows you why. ROAD RANGERS actually are two-range transmissions, with five speeds in each range and a synchronized power shift between ranges.

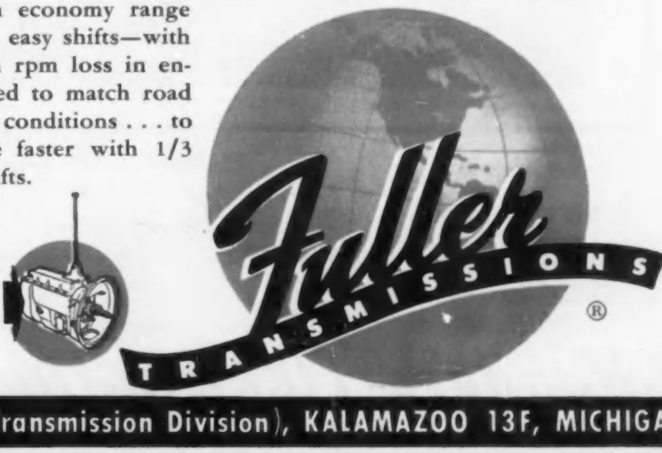
Speeds are spaced so that every ratio is a usable ratio in 28% steps that are equal, selective and progressive.

Your driver finds it easy to use his head more, his "foot" less . . . to keep his engine turning in the maximum economy range by quick, easy shifts—with minimum rpm loss in engine speed to match road and load conditions . . . to get there faster with 1/3 fewer shifts.

It's as simple as that . . . you keep engine rpm up—and you keep trip costs down by saving time, saving fuel, and relief of driver fatigue.

If you haven't seen a ROAD RANGER in operation yet, plan to do so at once. You'll see horsepower really put to work in the most efficient way possible.

where horsepower goes to work



FULLER MANUFACTURING COMPANY (Transmission Division), KALAMAZOO 13F, MICHIGAN

Unit Drop Forge Division, Milwaukee 1, Wis. • WESTERN DISTRICT OFFICE (SALES & SERVICE—BOTH DIVISIONS), 1060 E. 11th Street, Oakland 6, Calif.

Personals

Continued

FRED M. WINN, JR., formerly a sales engineer with Diesel Power Co., Tulsa, Okla., is now a transportation officer with the U. S. Navy. Winn is stationed at Little Creek, Va.

ARTHUR H. ZEITZ, JR., research engineer with Ethyl Corp., has been transferred from the Detroit laboratories to the research laboratories at San Bernardino, Calif.

C. L. NELSON, formerly at Flint Mfg. Division of GMC Chevrolet Division, is now at Chevrolet-Tonawanda in Buffalo, N. Y.

ROBERT E. CLARK, who was a project engineer in Detroit for Chrysler Corp., is now production contact engineer for Chrysler in New Orleans, La.

LEONARD C. FISHER has been promoted to assistant district sales manager for Aluminum Co. of America in Cincinnati, Ohio. He was previously assistant product manager.

EDWIN S. LEICHTMAN, who was formerly with the Bureau of Yards and Docks in Washington, D. C., is now special contracts application engineer with Cummins Engine Co., Columbus, Ind.

JOHN B. COLE is now associated with the Nylon division of Chemstrand Corp., Philadelphia. He was formerly president and manager of Cole, Inc., Fort Walton, Fla.

A. A. BRADD is now a roll engineer with Midvale Co., Philadelphia, Pa. He was previously with Arcos Corp. of Philadelphia.

F. P. ZIMMERLI, chief engineer of Barnes-Gibson-Raymond Division, Associated Spring Corp., Detroit, has been elected to the board of directors of the American Society for Testing Materials.

F. T. H. BRADLEY, chief engineer of Basrah Petroleum Co., Ltd., Basrah, Iraq, is on an extended leave to the United Kingdom.

JAMES R. COWDERY, who was formerly assistant product engineer for Cleveland Graphite Bronze Co., Cleveland, Ohio, is now designer for Lewis-Shepard Products Co., Watertown, Mass.

NORMAN C. CARD, JR., is a mechanical engineer on plant maintenance for Shawinigan Resins Corp., Springfield, Mass. He was formerly an instructor at the University of Massachusetts.

WENDELL A. HUBBELL, formerly fuels and lubricants engineer Standard Oil Co. of California in Los Angeles, is now senior fuels and lubricants engineer for that company in Salt Lake City, Utah.

HERBERT R. KEESY is now a process engineer at the new Ford Engine Plant, Cleveland, Ohio. He was previously with the product engineering department of Dearborn Motors Corp., Birmingham, Mich.

RICHARD ABOWD, JR., who was in training with the National Machinery Co., Tiffin, Ohio, is now at the University of Michigan doing graduate work in the Department of Mechanical Engineering.

R. M. McMILLIN has been promoted to experimental test engineer at the Chevrolet engineering laboratory, Detroit. McMillin was formerly laboratory assistant.

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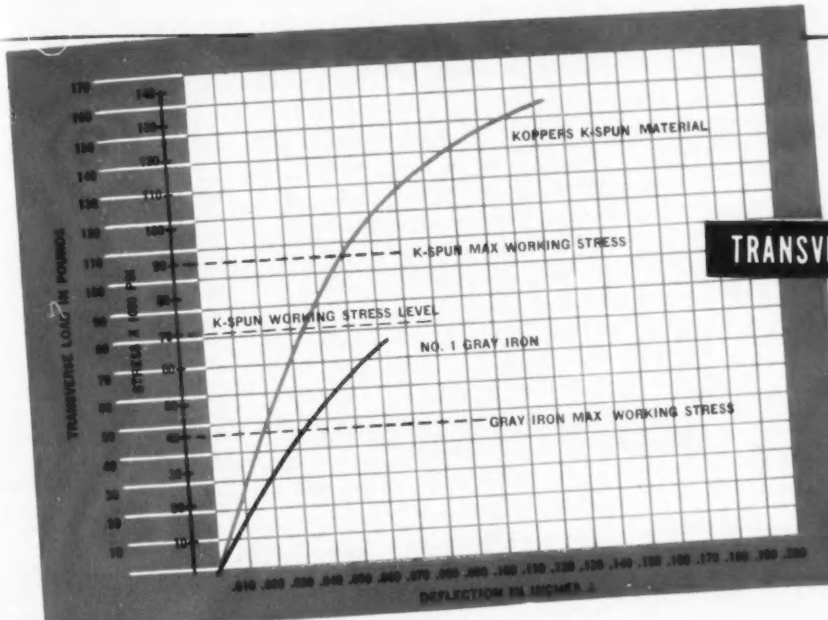
Here's PROOF that Koppers K-Spun Piston Rings are TWICE AS STRONG!



HERE ARE THE AMAZING RESULTS OF ACTUAL LABORATORY TESTS COMPARING ORDINARY GRAY IRON WITH KOPPERS K-SPUN, *THE MIRACLE METAL!*

TRANSVERSE STRESS CHART

Koppers K-Spun material shows a maximum working stress of 90,000 psi, compared with a maximum working stress of *only 40,000 psi for ordinary gray iron piston ring material!* Note the difference in the slopes of the two curves, due to K-Spun's increased modulus. K-Spun's yield point, though approaching ultimate strength, is low enough to allow a small percentage of elongation, resulting in toughness and impact value *many times greater* than that of ordinary gray iron.

TABLE 1—TRANSVERSE MODULUS AND RUPTURE STRESS

Koppers K-Spun Material			No. 1 Gray Iron		
TRANSVERSE MODULUS at			TRANSVERSE MODULUS at		
40,000 # psi	60,000 # psi	90,000 # psi	40,000 # psi	60,000 # psi	90,000 # psi
22.0×10^6	20.6×10^6	18.6×10^6	12.4×10^6	10.8×10^6	... .
RUPTURE STRESS psi			RUPTURE STRESS psi		
130,000			67,000		

TABLE 2—HARDNESS, IMPACT AND TENSILE STRENGTH

Koppers K-Spun Material			No. 1 Gray Iron		
Hardness R_b	Impact in lbs.	Tensile Stren., psi	Hardness R_b	Impact in lbs.	Tensile Stren., psi
100-103	9.5- 9.5	75,400	102-104	2.5-3.0	42,000
98-100	11.0-11.5	72,900	103-104	2.5-3.0	40,000
105-106	7.0- 5.0	76,000	101-103	3.0-3.0	41,000
99-102	7.0- 8.0	79,100	103-105	2.5-3.0	42,000
98-100	8.5-10.0	76,500	104-105	3.0-3.0	42,300
103-104	6.0- 7.0	77,500	102-103	3.5-3.5	38,000
101-102	7.0- 8.5	78,000	104-105	2.5-2.5	40,000

POROUS CHROME PISTON RINGS

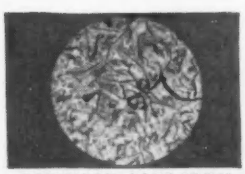
. . . another Koppers Exclusive!

Koppers Porous Chrome Rings reduce cylinder wall wear 50% or more by actual test! Famous Van der Horst Plating Process provides a porous chrome surface that distributes oil for better lubrication during break-in, wears down to perfectly seated solid chrome that gives up to four *times as much service* between overhauls! For gasoline and Diesel engines (on specification).

KOPPERS

HERE is a ring that provides better oil control, lasts far longer than ordinary rings, is *guaranteed against breakage for the life of the engine!* Read for yourself these facts and figures, developed in thorough laboratory tests . . . *clear demonstration that K-Spun Rings are 100% stronger and four times more resistant to combustion shock than ordinary rings!* Get the facts on Koppers K-Spun Piston Rings for *your* engine today . . . write for complete information to: KOPPERS COMPANY, INC., *Piston Ring Dept.,* 1530 Hamburg St., Baltimore 3, Maryland.

K-SPUN IS AN ENTIRELY DIFFERENT KIND OF RING MATERIAL



ORDINARY CAST IRON

KOPPERS K-SPUN

These microstructures, magnified 250 times, show the basic difference between ordinary cast iron and Koppers K-Spun. Top photo shows individually cast gray iron, containing spiral flake graphite with long stringers in a fine pearlitic matrix. This fine flake graphite imparts to the metal many planes of weakness, causing low resistance to combustion shock.

Bottom photo shows K-Spun, cast by an exclusive centrifugal process. Note large nodular type of graphite formation and absence of stringers. Large graphite nodules eliminate the many planes of weakness inherent in most cast iron . . . double impact resistance and elasticity . . . increases wear resistance by far . . . in amazing Koppers K-Spun Piston Rings!

KOPPERS *American Hammered* PISTON RINGS

Personals

Continued

LT. ARTHUR B. COOK is now stationed at Wright-Patterson Air Force Base, Dayton, Ohio, where he is a development engineer. Prior to entering the Air Force, Cook was experimental flight test inspector for McDonnell Aircraft Corp., St. Louis, Mo.

ANTON KRAPEK, formerly assistant heating engineer for Lansing Supply Co., has joined Reo Motors, Inc., also of Lansing, Mich., as layout draftsman and senior detailer.

PAUL BANCEL is now a senior project engineer with General Motor's Allison Division, Indianapolis, Ind. Bancel was formerly powerplant engineer for Fairchild Engine and Airplane Corp., NEPA Division, in Oak Ridge, Tenn.

FRANK H. WEBSTER has been promoted to assistant manager, Western Division, of GMC Hyatt Bearings Division in Chicago, Ill. Webster joined the Hyatt organization in 1925 as a sales engineer in the Oakland, Calif. office. He was transferred to the Chicago office in 1938.

ROBERT E. COHEN has accepted a commission in the U. S. Naval Reserve. Cohen reported for active duty Sept. 25.

LLOYD W. SCHUHMANN, who was a production engineer for Chrysler in Detroit, is now divisional superintendent in the Chrysler Tank Engine Plant, New Orleans, La. Schuhmann is responsible for the production of major steel parts.

HARVEY S. FIRESTONE, JR., chairman of Firestone Tire & Rubber Co., has announced plans for the construction of a $4,000,000 tire and tube manufacturing plant at Valencia, Venezuela.

HAROLD C. NIMRICK is now assistant superintendent of Northwest Metal products, Inc., Kent, Wash. Nimrick was previously president of his own company.

THEODORE A. LENDA is now a senior mechanical engineer with Raytheon Mfg. Co., Newton, Mass. Lenda was formerly a design engineer with Fairchild Engine and Airplane Corp., NEPA Division, Oak Ridge, Tenn.

PAUL E. HITCH, formerly project engineer with Chevrolet-Indianapolis Division, has been transferred to Chevrolet Aviation Engine Division, Buffalo, N. Y.

DONALD B. MILLER, formerly chief engineer with Race & Race, Inc., is now a powerplant evaluation engineer on propellers with the Civil Aeronautics Administration, Washington, D. C.

ALFRED F. ANDERSON, JR., is supervisor, customer delivery, with the Gulf Oil Corp., Pittsburgh, Pa.

WALTER L. CLOSE is now development engineer with Aireseach Mfg. Co., Los Angeles. He was formerly powerplant engineer with Eastern Air Lines, Inc., Miami, Fla.

CHARLES M. ADAMS, formerly sales and service engineer with the Waukesha Engine & Equipment Co. in Denver, Colo., is now district manager of that company in Farmington, New Mexico.

GEORGE K. FLOROFF is a project engineer with Wright Aeronautical Corp., Wood-Ridge, N. J. He was previously senior analytical engineer with Pratt & Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn.

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Personals

Continued

B. M. SCRIVER, who was previously associated with Consolidated Engines and Machinery Co., Ltd., of Montreal, is now with Project Sales, Ltd., in the same city.

THOMAS J. THOMPSON, who was a project engineer with Bendix Products Division of Bendix Aviation Corp., is now an accessories engineer with Lincoln-Mercury Division of Ford Motor Co., Detroit.

SINCLAIR F. CULLEN is a student engineer with the Hydraulic Division of Sundstrand Machine Tool Co., Rockford, Ill.

ALEXANDER HOSSACK, formerly test engineer with the Hudson Motor Co., Detroit, is now project engineer at the Ordnance Tank and Automotive Center, Centerline, Mich.

EDMOND LOUIS PATTON, JR., is a draftsman with the Chicago Bridge and Iron Co. He was formerly experimental test engineer with Pratt & Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn. Patton is training in the design and application of steel fabricated structures.

MORRIS J. DUER, formerly a designer with Ingersoll Milling Machine Co., is now with the Allison Division, General Motors Corp., working on layout and design.

JOHN FESTIAN, who was with Ford Motor Co., is now a product design draftsman with the Packard Motor Car Co., Detroit.

LT.-COM. JOSEPH A. TANTET is now with the Navy Department's Bureau of Ships in Washington, D. C. Commander Tantet was formerly associated with California Research Corp., Richmond, Calif.

GILBERT W. STEVENSON is now assistant director of the cold-work laboratory at Watertown Arsenal, Watertown, Mass. Stevenson was previously proprietor of Automotive Steam Research, also in Watertown.

FRANK W. PERSON, formerly senior radiator design engineer with Fedders-Quigan Corp., Buffalo, N. Y., is now chief of radiator development for International Harvester Co. at the Melrose Park, Ill., works.

HARLAN D. FOWLER, formerly an independent consulting aeronautical engineer, is now with the Air Force Intelligence Division at Wright-Patterson Base, Dayton, Ohio. He is supervisor of the aerodynamics, structural and dynamics sciences group.

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Personals

Continued

THOMAS CHLEBINA, formerly boiler assembly designer for Wickes Boiler Co. in Saginaw, Mich., is now production designer with Goodyear Aircraft Corp. in Akron, Ohio.

LAPE W. THORNE is now general manager of Lake GMC Truck Sales, Inc., in Cincinnati. He was formerly salesman for General Truck Sales, Inc. Thorne is 1951-52 secretary of SAE Cincinnati Section.

LT.-COL. EARL W. HAEFNER is now on special assignments with the procurement divison of Standards Branch, G-4 General Staff, at Army Headquarters in the Pentagon Building, Washington. Haefner is on leave of absence from Borg-Warner International Corp. in Chicago, Ill.

CLAYTON L. NELSON is now associate resident engineer at Chevrolet-Tonawanda Division of General Motors Corp., Buffalo, N. Y. Nelson was formerly assistant resident engineer at Chevrolet's Flint Mfg. Division. He was chairman of the Mid-Michigan Section for 1950-51.

GIVEN W. SPRAGINS, formerly service manager for Ray Novak Motor Co., Falls City, Neb., is now an Ordnance Corps automotive technician at Fort Sheridan, Ill. He will advise and train military personnel in methods of organizational maintenance of ordnance equipment.

RAYMOND F. HALEN has joined the Parker Appliance Co., Cleveland, as aircraft sales engineer, it is announced by **D. W. HOLMES**, vice-president in charge of sales. Halen, who will handle specific jet engine and air frame accounts, principally in the East, was formerly with Hydro-Aire, Inc., as a sales engineer.

ROBERT SWAN is now an industrial sales engineer with Aero-Coupling Corp., a subsidiary of Aeroquip Corp., of Burbank, Calif. He will represent the company in Northern California and Nevada. Swan was previously associated with West Coast Engine and Equipment Co., Berkley, Calif.

KNUD ANTONSEN is now design engineer in the general engineering laboratory of General Electric Co., Schenectady, N. Y. Antonsen previously held the same position with Fairbanks, Morse & Co., Beloit, Wis.

AARON N. WALDMAN is now a design engineer in the television division of Westinghouse Electric Corp. at Raritan, N. J. Waldman was formerly a research engineer for Bendix Aviation Corp. in Teterboro, N. J.

DONALD H. SNYDER, formerly associated with Nash-Kelvinator Corp., Kenosha, Wis., is now a project engineer in the Engineer Research and Development Laboratories at Fort Belvoir, Va.

W. J. POWER is officer in charge of spare parts stores section of the Canadian Department of National Defense at Hochelga, Montreal. He is responsible for the provision, identification, and issue of spare parts to civilian contractors and national workshops. Power was previously with the Royal Canadian Electrical and Mechanical Engineers.

Continued on Page 114

Personals
Continued

WILLIAM P. BARNES, who was an instructor in the department of mechanical engineering of the University of Oklahoma, is with the National Advisory Committee for Aeronautics in the Lewis Flight Propulsion Laboratory at Cleveland Airport.

MALCOLM K. JOHNSON, who was previously head mechanic for Wisconsin Central Airlines at Municipal Airport, Madison, Wis., is now airplane and engine mechanic with Western Airlines, Inc., in Los Angeles.

WARD H. BRIGHTON has joined Redmond Co., Inc., Owosso, Mich., as sales engineer. Brighton formerly held the same position with M B Mfg. Co. of New Haven, Conn.

JOSEPH GRABER is now with Halm's New York-Pittsburgh Express, Inc., in Pittsburgh. Graber was previously superintendent of maintenance for Continental Freight Forwarding Co.

HENRY DURR has joined Reo Motors, Inc., Lansing, Mich., as application engineer in the industrial and marine engine division. Durr was previously associated with Erie Malleable Iron Co. in Erie, Pa.

RENE G. DUBOIS, who was a distributor of automotive supplies in Cape Town, South Africa, is now in Indianapolis as a project engineer with GMC Allison Division.

L. B. LITTLE has joined Hancock Trucking, Inc., Evansville, Ind., as general maintenance manager. Little was formerly branch service manager of White Motor Co. in Milwaukee.

H. KNOX PERRILL, who was formerly assistant to the president of Bill Jack Scientific Instrument Co., Solana Beach, Calif., is now project engineer in the guided missile production division of Hughes Aircraft Co., Culver City, Calif.

GEORGE A. HIRSHMAN has been promoted to administrative engineer for GMC Oldsmobile Division. Hirshman was previously supervisor of experimental records.

E. M. ANDERSON, who was formerly foreman for Redifer Bus System, is now with Hertz Drive-Ur-Self Stations, Inc., as superintendent of maintenance.

F. A. JENNINGS is now research engineer in the propulsion development group of the aerophysics and atomic energy research division of North American Aviation, Inc., Downey, Calif. Jennings was formerly associated with National Seal Co. in Van Wert, Ohio.

FRAM stands for QUALITY

In major plants across the nation, in modern laboratories and engineering facilities, the byword at Fram is *quality*. It's the kind of quality that comes from precise filtration engineering translated into vast production.

From these plants have come the Fram Firsts that advanced engineered protection for the products of the automotive industry. Fram quality has molded the decision of over 70 leading manufacturers of cars, trucks, tractors, buses and engines to use filters embodying the Fram Principle of Oil Filtration on some or all of their vehicles.

Bring your filtration problems to Fram. Fram Corporation, Providence 16, R. I. *In Canada:* J. C. Adams Co., Ltd., Toronto, Ontario.

Manufacturers of...

FRAM OIL & MOTOR CLEANERS • FRAM FILCRON REPLACEMENT CARTRIDGES • FRAM CEL-PAK REPLACEMENT CARTRIDGES • FRAM FILTRONIC REPLACEMENT CARTRIDGES • FRAM CARBURETOR AIR FILTERS • FRAM GASOLINE FILTERS • FRAM CRANKCASE AIR FILTERS • FRAM POSITIVE CRANKCASE VENTILATORS • FRAM RADIATOR & WATER CLEANERS • FRAM FUEL OIL FILTERS • FRAM INDUSTRIAL OIL AND FUEL FILTERS • FRAM COMBINED SEPARATOR-FILTER FOR IMMISCIBLE LIQUIDS • FRAM CUSTOM-DESIGNED FILTERS FOR SPECIALIZED APPLICATIONS.

FRAM
OIL • AIR • FUEL • WATER
FILTERS

New Members Qualified

These applicants qualified for admission to the Society between Aug. 10, 1951 and Sept. 10, 1951. Grades of membership are: (M) Member; (A) Associate; (J) Junior; (SM) Service Member (FM) Foreign Member.

Buffalo Section

Fred A. Stenning (J), Donald Stoltman (J), Eugene Willihnganz (M).

Canadian Section

Reny Barki (J), William L. McGinnis (M), J. B. Van Der Hout (A).

Chicago Section

Richard A. Anderson (A), Frank Bott (A), Edward Brenner (J), Boris B. Brouevitch (A), William G. Doke (J), Robert Jack Gyllenswan (J), Edward H. Johnson (A), Fay Eugene Kaiser, Jr. (J), Elwood W. Krueger (A), Robert L. May (M), Robert John Neubacher (J).

Cincinnati Section

Carl F. Bennett (A), Robert E. Broxon (A), Charles L. Hebel (J), John F. Scanlon (A).

Cleveland Section

Everett L. Baugh (M), John E. Carnahan (M), John T. Crawford (M), Paul M. Hetrick (J).

Dayton Section

Thomas L. Deger (J), Harold Walter Herring (M).

Detroit Section

Harold A. Beatty (M), George Brenz (M), Robert Loren Burns (J), William K. Burton (M), Robert H. Carter (M), William J. Clark (M), John Dorian (J), John Dykstra (M), William Stanley Edwards (J), E. B. Evans (A), Lawrence J. Gilsdorf (J), William Harms (M), Donald H. Hartmann (J), John G. Haviland (M), Edward D. Heins (M), Johannes Kamuk (J), John A. Krolicki (M), E. D. Marande (M), Thomas T. Mikaelian (J), Albert Resnick (SM), G. Scott Sample (A), Charles David Simmons (J), Donald D. Simpson (M), Walter H. Simpson (M), Miss M. Virginia Sink (M), Walter F. Skinner (A), Chris L. Sloman (A), G. Neilan Smith (J), A. E. Stanyar (M), Jeremy J. Stevens (J), F. Ely Strohm (M), Carson M. Wallace (A), Jervis C. Webb (M), B. H. Weil (M).

New Members Qualified
Continued

Indiana Section
John Forrest Geneva (J), William M. Myers (M).

Kansas City Section
Leonard R. Buff (M), Kenneth Flint Long (J), Claude A. McComb (M).

Metropolitan Section
Clements J. Boyers (A), Gerald Paul Clericuzio (M), John S. Davey (A), Paul DeSamelson (A), William N. Fenney, Jr. (M), Richard S. Ferris (A), Harry Gelbach (M), Vincent J. Grande (A), J. Frederic Johnson (M), Edmund J. Rotchford, Sr. (A), Pedro Juan Sintes (SM), John H. Smithson (M), Robert M. Whelan (J), Alfred K. Wright (M), Daniel Yawnick (A).

Mid-Continent Section
Glenn E. Holman (J).

Mid-Michigan Section
F. Richard Merriam (M).

Milwaukee Section
Raymond W. Fabere (M), John R. Parker (M).

Montreal Section
L. Jacques Cartier (M), Joseph A. De Grace (A), Philip B. French (M).

Northern California Section
Robert M. Snyder (M).

Oregon Section
Ancel S. Page (M).

Philadelphia Section
George M. Bunn (M), Kent Hyatt (M), Robert Charles Lederer (J).

St. Louis Section
Harold Kramer (M), Robert G. McCullough (M), Thomas L. Walker, Jr. (J).

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New Members Qualified

Continued

San Diego Section

Ernest F. Mellinger (M), Murray Ogman (J).

Southern California Section

George N. Bennett (M), Arthur L. Birdsall (M), Arthur William Brooks (A), M. K. Carter (A), Dan L. Hicks (A), Albert H. Ross (A).

Southern New England Section

Albert I. Alstrom (M), C. E. Holtsinger, Jr. (M), Erling D. Sedergren, (M).

Syracuse Section

Robert S. Seidel (J).

Texas Section

Nolan J. Clark (M), I. G. Kennon, Jr. (M), David Charles Weiss (J).

Twin City Section

Robert F. Piculell (A), Farris Hardin Woods (M).

Washington Section

Ray P. Teele (SM).

Western Michigan Section

William Keller McInerney (M), Joe L. Talbott (A).

Wichita Section

Cordy Wiley Jones (A).

Outside of Section Territory

Howard C. Aldridge (M), William R. Chillingsworth (A), Herbert C. Morris (M), Harold L. Sanders (J), 2nd Lt. Harold Silver (J), Harold O. Skinner (A), Walter John Thiede (M).

Foreign

Paolo Beltramo Ceppi (FM), Italy; H. C. Graftiau (FM), Belgium; Albert Phillip Hickson (FM) England; Eugene L. Towle (J), Mexico; Raymond P. Vincent (FM), Scotland; Gale T. Warner (A), India; James Waugh (FM), England.

Applications Received

The applications for membership received between Aug. 10, 1951 and Sept. 10, 1951 are listed below.

Atlanta Group

J. W. Griffith.

Baltimore Section

Harry Wilson Reynolds, Jr., Gary Gray Sinton.

Buffalo Section

Henry K. Lanz, J. Gerald York.

Canadian Section

George William Burley, Reginald Hill, W. C. Stewart, Charles O. Wallin.

Chicago Section

Andrew Alfred Affrunti, Leslie L. Andrus, Charles Francis Bremigan, Jr., Raymond A. Church, Howard E. Dahl, Robert T. Daily, Mark Dick, F. Marion Hogue, William Arthur Kolinger, Harold W. Logan, Walter J. Moeller, R. J. Packard, Richard John Rayer, Leonard Walter Szymanski, George Merlin Tam, John Urbanski, Robert Richard Vehe, David E. Waite.

Cincinnati Section

Howard L. Finn, James F. Green, Robert K. Ruehrwein.

Cleveland Section

L. R. Barr, H. K. Biehl, Allen M. Bower, William S. Gleeson, Harold H. Humpal, George B. Josten, George A. Kallas, Robert William Lasher, Harold Emil Riedel, John W. Spring, Harold H. Stroebel, Rudy J. Zikesch, Frank W. Zurn.

Dayton Section

Jack R. Allen, Michael Joseph McInerney.

Detroit Section

Truman F. Barbier, Jr., Albert E. Blandford, Lewis D. Crusoe, Rudolph J. de Santo, Richard L. Exler, L. T. "Larry" Flynn, Bennett Roy Gardner, Glen G. Greene, Everett Gregg, William A. Kelley, Harold W. Krieger, Bruce Edmond Lamm, James A. Leake, Allen E. Light, William Cram Morgan, Robert L. Nance, Edward John Pawlak, John B. Penniman, Fletcher N. Platt, R. C.

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Applications Received

Continued

Richardson, James M. Robbins, Rober L. Robinson, Arthur A. Rubly, Lyle H Russell, René E. Sauzedde, Joseph Frank Sbarra, David Joseph Sharp Louis R. Sisson, Dwight Carlton Spry Frederick A. Stewart, Glenn William Thebert, Robert Gerald Thom, Jules Van Deun, Edmund J. Wayne, John A Yntema, Walter C. Zetye.

Indiana Section

Walter M. Horner, Howard J. Hutsell, Harry A. May, Mike Rivilis, James D. Sauer, Robert Elsworth Thomas.

Kansas City Section

Joseph J. Waldman.

Metropolitan Section

Bernard I. Fisher, Norman J. Freund, Joseph Gehringer, Joseph P. Gorski, Frank J. Horsch, Jr., Harold P. Schaller, George Francis Sheridan, Herbert M. Toomey.

Mid-Continent Section

John Howard Koch.

Mid-Michigan Section

Gordon S. Marvin, Paul H. Morehead.

Milwaukee Section

Lee Delaney, Lawrence E. Lenz, Milton G. Mardoian, Norman Paul Mollinger, Lawrence Charles Olsen, Dan M. Zelinger.

Montreal Section

I. Finkelstein, Norman Robert Hain, R. F. Stapells, James W. Ussher, Jason J. Waller.

New England Section

Earl N. Comeau, Robert G. Douglass, Michael John Theodore, Clarence E. Thomasy, Ernest C. Trimper.

Northern California Section

Bruce Edward Boswell, Leland D. Chamness, 2nd Lt. Shelby O. Martin.

Northwest Section

Vaughn H. Dorsey, William L. Hubka, Richard W. Wells.

Oregon Section

John E. Olson, Lyle R. Patterson, Carl G. Santesson.

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Applications Received
Continued

Philadelphia Section

Richard Collett, Michael R. Famiglietti, Robert H. Gasch, Jr., George H. Harris, John Morgan Richards, Victor J. Tomsic.

Pittsburgh Section

John S. Trogner.

San Diego Section

Mark Roland Miller, Wesley Oliver Reed.

Southern California Section

Warren H. Clark, Ralph Gonzales, Alvin Gorenbein, Robert A. Morrison, Earl F. Noyes, Robert S. Petersen, Frank Edward Pilling, Jr., Berle E. Rabenberg.

Southern New England Section

Charles Robert Johnson.

Texas Section

William L. Jenkins, Kenneth Dale Mills, Joe L. Neveux, Warren H. Sullins.

Twin City Section

Edward Samuel Kellermann, Jr.

Western Michigan Section

Carl Seger Lundgren.

Wichita Section

Richard Hughes.

Williamsport Group

Earl W. Feese, Maurice Goldfinger, Heinz F. Moellmann.

Outside of Section Territory

Russell Candee, Robert K. Cooper, Quentin William Crane, 2nd Lt. William A. French, Dale G. Gubbins, Frank B. Henry, Jr., Thomas Reese Kirkman, Warren W. McCaw, Desle O. H. Miller, Harold F. Neuberger, W. D. Popek, Bernard E. Ross, Franklin B. Rote, Jack G. Swim.

Foreign

Thomas Alva Fisher, New Zealand; Wilfrid Metcalfe, England.

For the Sake of Argument

How Do You Take It?

By Norman G. Shidle

"Life is 10% what you make it; 90% how you take it."

That's about the same as saying attitude governs results more than skills do. . . And we think there is something in it.

Take the fellow who knows perfectly how to do a job, but doesn't finish it. The boss won't like his attitude. He is likely to be less useful to have around than a pretty fair operator who finishes what he starts.

One man will attack his problems; have momentum when he hits them. Another will let the problems gain momentum; do his best to hold the line when *they* hit *him*. Attitude makes the difference in attack. The attack makes the difference in the results.

Facing troubles or frustrations, one man's attitude will reflect self-justification, martyrdom. His anger will cloud his thinking. Another will try to think his way out, saying: "it's better to light a candle than to curse the dark."

Start to explain a project to one man, and you can feel without words the presence of a "how-can-I-help" attitude. Bring the same project to another and you can feel everything from "I'll-bet-it's-a-turkey" to "Why-pick-on-me?"

In an organization, a right attitude means more than just getting along with people. It means (as Henry Jones said recently in *Printers Ink*) "reflecting a wholesome, friendly feeling inside. . . A man has every right to be an individual, to be independent . . . But outward actions and speech should reflect a decent respect for his fellow workers, his boss, and his business."

The way you take life does shape what you make of it.

—PARCO COMPOUND

Parco Compound, constantly improved over the past third of a century, now offers greatest efficiency and economy in the protection of iron and steel against rust and corrosion.

In addition to rust resistance, Parco Compound adds greatly to the attractive appearance of the treated parts. When it is combined with stains or oils, a very dark satin finish is produced. Treated metal may be waxed, or may be painted with excellent results.

While efficiency and flexibility has increased, cost is still extremely low. Treatment with Parco Compound is quick, simple, uniform, completely dependable. The only limitation on size of parts treated is the size of the processing tanks.

Parco Compound meets government specifications for military use, and is replacing cadmium and zinc in many civilian applications.

**Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.*

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Detroit 11, Michigan

BONDERITE—corrosion resistant paint base • **BONDERITE and BONDERLUBE**—aids in cold forming of metals • **PARCO COMPOUND**—rust resistant • **PARCO LUBRITE**—wear resistant for friction surfac